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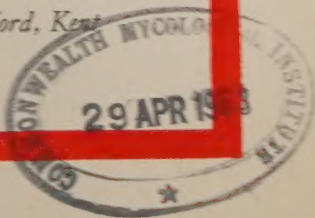
WYE COLLEGE

Department of Hop Research

ANNUAL REPORT

1954

*Copies of this Report may be obtained, price 5/-, from
the Secretary, Wye College, Nr. Ashford, Kent*



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(Published June 1955)

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DEPARTMENT OF HOP RESEARCH

INTRODUCTION

Since the report published a year ago, there have been no staff changes and the research team has been able to settle down to its work under the able leadership of Mr. H. Darling, untrammelled by interruptions resulting from resignations and new appointments. The team, however, is as yet incomplete. Approval has been given to the appointment of a pathologist, and it is hoped to confirm this essential appointment in the near future; it is also hoped that it will prove possible to appoint someone with the requisite training to make growth studies of the hop plant, as such studies are becoming of increasing importance to the development of several aspects of the work of the Department. When these two additional posts have been filled, it is felt that the Department will be adequately staffed, though such a pious hope is always dangerous to express in the field of applied research work in which the unexpected invariably seems to develop.

The surveys on the machine picking of hops are not to be continued, at any rate, for the present. The results of the surveys carried out over the last few years have been summarized and a report thereon published. It is, however, not the intention to abandon this increasingly important aspect of the work, but to maintain the closest contact with those farmers making use of picking machines, and it is much hoped that our colleagues of the National Institute of Agricultural Engineering at Silsoe in Bedfordshire will be able to participate closely with the technical development of the machines now available. The Department itself is not equipped for such highly technical studies which would seem to fall more properly into the sphere of the N.I.A.E.

Last year saw the completion of the conversion of the main oast to oil firing, with the adaptation of the two larger kilns, formerly steam heated, to the more standard oil-burning equipment. The kilns are now very well equipped to deal with both the larger "commercial" crop and with the smaller lots from the experimental plots. They were well tested out under the difficult conditions prevailing at hop picking time last year and amply proved their value.

Once again, the College is grateful for an opportunity of recording its thanks to all those authorities and individuals who have supported the work of the Department and whose lively interest in its many problems have been such a source of encouragement, both to the College as a whole, and, in particular, to the staff of the Department. It gratefully acknowledges the grants made available for the work from the Ministry of Agriculture, and, through the Ministry, from the Hops Marketing Board and the Institute of Brewing. It also desires again to record its appreciation of the willing help and co-operation it has received from the Agricultural Research Council, the Brewing Industry Research Foundation, from growers, and from its many colleagues at East Malling Research Station and within the National Agricultural Advisory Service.

During the last few years, the work and scope of the Department has somewhat changed. Its one time advisory duties have been relinquished to the N.A.A.S. and now, well staffed and equipped, its primary concern is with problems of applied research and investigation. None the less, it is very pleasant to be able to record that, in spite of such changes, the Department has not only maintained but increased its close contacts with growers, particularly in the West Midlands, through the very happy relationship which has developed with our colleagues at the Rosemaund Experimental Station.

DUNSTAN SKILBECK,

Principal.

May, 1955.

GENERAL REVIEW

CLIMATE

The growing season of 1954 was one of the worst on record. Meteorological data for Wye are given below:

Month	Rainfall in inches		Sunshine in hours per day	
	1954	Average 1935-54	1954	Average 1935-54
April	0.26	1.72	6.50	5.88
May	1.92	1.94	6.00	6.83
June	3.22	1.73	5.40	7.44
July	3.33	2.16	4.50	6.98
August	3.70	2.43	4.90	6.47
September ..	2.13	2.41	5.00	5.05

April was extremely dry, the rainfall of 0.26 inches in this month being the lowest on record. By contrast, June, July and August were very wet, totalling 10.25 inches of rain as compared with the 1935-54 average of 6.32 inches for these three months. This 1954 total of 10.25 inches is the second highest in the twenty years covered by the above table, being only exceeded by the 10.87 inches recorded in the exceptionally wet summer of 1946.

The high summer rainfall was associated with a degree of cloud cover which markedly reduced the incidence of sunshine. The average number of hours per day of sunshine in 1954 for the months of June, July and August was only 4.97 compared with the 1935-54 average of 6.96 hours, and was the lowest on record.

Comparable summarized data on temperatures at Wye are not available, but information kindly given by Mr. L. G. Kimmins for Ashford (4½ miles from Wye) shows that the 1954 summer ranks with that of 1938 in being the coldest in the past twenty years. It was the first summer on record in which the mean screen temperature for any month was less than 60° F. Screen maxima reached 70° F. or more on only 36 days as compared with 101 days in 1947. The July of 1954 was the coldest for more than thirty years.

PESTS AND DISEASES IN THE COLLEGE HOPS

Attack by the Hop Flea Beetle, *Psylliodes attenuata*, was very obvious in early May on young shoots which were suffering from the

retarding effect of the April drought. This attack did not appear to cause serious harm, and it died away as the plants entered into full growth in late May.

Winged migrants of the Hop Damson Aphis, *Phorodon humuli*, invaded the crop in mid-May and apterous adult females were observed on May 24th when the vines had reached a height of 6 to 8 ft. Aphid populations rapidly increased to serious levels in all gardens. This pest was well controlled throughout the season by spraying with Schradan. Three applications in all of this systemic insecticide were made on May 27th-31st, June 17th-18th, and July 15th-16th respectively. Winged migrants were still observed to be arriving in the crop in early August, and as a precaution against a late attack in the ripening cones, a spray of TEPP was applied on August 16th-17th.

Red Spider, *Tetranychus urticae*, was never serious though symptoms of light attack were noticed towards the end of the season in young plants in the propagation rows. Presumably this pest was discouraged by the damp cold summer and by the regular applications of Schradan sprays.

Incipient outbreaks of mould disease, *Sphaerotheca humuli*, were observed on susceptible varieties from May onwards and were controlled by dusting with sulphur at regular intervals throughout the summer.

During the winter of 1953-54, downy mildew disease, *Pseudoperonospora humuli*, killed appreciable numbers of hills in Silks and Wye Field Gardens. The varieties mainly affected were Early Bird Goldings in Silks and John Ford in the Height of Wirework and Spacing Trial in Wye Field. The affected hills were grubbed and replanted. This disease was satisfactorily controlled in all gardens throughout the growing season by spiking and by spraying seven times with copper fungicides. Copper oxychloride was included in the first and second Schradan sprays in May and June, and Bordeaux mixture at half strength (5 lb. copper sulphate per 100 gallons of water) was applied on June 30th and on July 8th-9th. Full strength Bordeaux mixture was applied on July 21st-22nd, on August 10th-13th, and on August 20th-21st. Wet and stormy weather in early August upset the spraying programme and in the middle of this month a localized outbreak of downy mildew occurred in the developing cones along the west side of Wye Field Garden. This outbreak did not continue for long nor did it spread far into the garden.

Canker or "growing off" disease, caused by *Fusarium* sp., was widespread and was more troublesome than usual. It killed an

appreciable number of bines in all three of the College gardens.

In the plant breeding rows a few hills of susceptible varieties were attacked by *Verticillium dahliae* and were grubbed. On August 7th, in the centre of the Height of Wirework and Spacing Trial in Wye Field Garden, a single hill of John Ford was found to be suffering from wilt disease and the pathogen was subsequently identified as *Verticillium albo-atrum*. This was the first record of *albo-atrum* on hops at Wye, and its incidence was a matter for grave concern. Immediate measures were taken to eradicate the disease and the College gardens were searched with great thoroughness periodically throughout the remainder of the growing season. These searches failed to reveal any further infected hills. The eradication measures have so far prevented the disease from showing by its behaviour in the garden, whether it is of the progressive or the fluctuating type. The fungus, however, has been isolated from material from the single affected hill and has been grown in culture. Arrangements have been made for a pathogenicity test to be carried out at East Malling Research Station in 1955 to show which type of *albo-atrum* is involved. Meanwhile, the case found in Wye Field is being regarded as suspected progressive *Verticillium* wilt and suitable precautions are being taken in the care and management of the College hop gardens.

THE COLLEGE HOP CROP

The reorganization of the Nursery Garden was started in the winter of 1953-54 and about two acres of hops were grubbed, rewired and replanted. This is discussed in more detail in the review of the plant breeding work given elsewhere in this report.

The 1954 crop got away to a late start owing to the April drought. Subsequent growth was rapid, and by the end of June the bines of mature hills had reached the top wires. The cool, damp summer, while favourable enough for vegetative growth, was not conducive to high yields. As shown below, the harvest was appreciably less than in 1953. Low temperatures and wet conditions combined to hinder pollination and to prevent the cones from developing fully. Ripening was late and uneven. Many of the hops reached the oast in a relatively green condition and the crop did not "weigh well" on drying. In 1954 a total of 38,781 bushels of green hops were picked, giving a ratio of 127 bushels per cwt. of dried hops. This compares with 120 per cwt. in 1953.

The total yield from the College hop gardens was 303 cwt. of dried hops as weighed at the oast in September-October; this was

50 cwt. less than in 1953. The main yield data for commercial varieties are given below. Corresponding data for 1953 are given for comparison:

		Yield per acre in cwts. dried hops	
		1953	1954
Silks Garden	Early Bird Golding ..	24.0	16.4
	Petham ..	24.1	19.5
	Eastwell ..	23.1	20.3
	Mixed ..	29.0	23.2
	Average ..	25.1	19.8
Wye Field Garden	Fuggle N. ..	25.4	22.3
	John Ford ..	26.2	18.5
	Bullion ..	30.0	23.8
	Brewer's Gold ..	27.6	22.7
	Average ..	27.3	21.8

It will be noted that in the commercial varieties grown in Silks and Wye Field Gardens the majority of yields were about 80 per cent. of those obtained in 1953. Two marked exceptions to this were the Early Bird Goldings and the John Ford, which yielded only 68 per cent. and 73.5 per cent. respectively of their 1953 totals. The extra drop in yield observed in these two varieties was almost certainly due to the effects of the grubbing and replanting of hills attacked by downy mildew, which was carried out in the previous winter.

Picking started on September 2nd and ended on October 5th, giving a possible maximum of $26\frac{1}{2}$ working days. About $2\frac{1}{2}$ working days were lost through bad weather and the number of effective picking days was 24. Difficulty was experienced in getting enough pickers, and, had the crop been a heavy one, the picking strength would have been inadequate. The College may soon be forced to consider buying a picking machine. Harvesting difficulties were increased by the presence of suspected progressive *Verticillium* wilt in Wye Field Garden. This prevented the moving of pickers from Wye Field to the other "clean" gardens and necessitated much duplication of effort.

For the first time the whole of the College crop was dried by direct oil-firing. This proved most successful. The College oast has six kilns, two large and four small, the performance of which is discussed below:

(a) Large kilns.

These two kilns formerly used air warmed by steam-heated radiators. In 1954 this complex heating system was replaced by direct oil-firing using Rotamisor burners. Each kiln has a floor space of 360 sq. ft. (18 ft. by 20 ft.), and is equipped with a constant speed fan giving an estimated air speed through the load of about 31 ft. per minute. These kilns are representative of good present-day commercial practice. Data from their use in the 1954 season are summarized as follows:

Number of loads dried	..	..	52	
Number of burner hours	..	..	506.5	
Fuel oil consumed	..	..	3,005	gallons
Burner hours per load	..	..	9.74	(from 8 to 12)
Fuel per load	..	..	57.8	gallons
Fuel per burner hour	..	..	5.93	gallons

(b) Small kilns.

These four kilns are small editions of the ordinary commercial type. They were built in 1952-53 to dry the yield of experimental plots, especially those of new varieties, and to provide samples of dried hops large enough for normal brewing trials. They are fitted with Kaloroil burners for direct oil-firing and have variable speed fans giving air speeds through the loads of up to about 40 ft. per minute. They normally work to give an air speed of about 30 ft. per minute. Each kiln has a floor space of 121 sq. ft. (11 ft. by 11 ft.). Data for these kilns for the 1954 crop are summarized as follows:

Number of loads dried	..	106	
Number of burner hours	..	972.5	
Fuel oil consumed	..	1,985	gallons
Burner hours per load	..	9.17	(from 7.25 to 12.5)
Fuel per load	..	18.74	gallons
Fuel per burner hour	..	2.04	gallons

The 1954 College crop has proved to be of good quality in spite of the poor season. Most of the commercial varieties fetched better than Grade I prices. Exceptions to this were the John Ford and the Fuggle, which were below Grade I, but well above Grade II in price. Both of these varieties were picked a little too green to give top grade. This was partly due to the poor summer delaying maturity and partly to the fact that the College gardens are not ideal for Fuggle hops, which appear to be better suited by the soils of the Weald.

Credit is due to the field staff of the Department for bringing the crop successfully through a difficult season, and especially to Mr. J. Ashby, the Hop Foreman, for his drying of the crop. In spite of the poor summer he has produced hops of a quality second to none in the history of the College.

RESEARCH AND GENERAL

A substantial part of the research work carried out during the year is covered by the papers and progress reports which follow, and such work is not discussed in this general review of departmental activity. This research has involved a considerable amount of routine work, including the analysis of more than 600 leaf samples, in which determinations of from six to eight elements were made on each sample, and the analysis of about 700 samples of dried hops for resin content.

This report includes two papers by F. H. Beard and Professor Salmon on 33 new varieties of hops at present growing in experimental plots in Wye Field Garden. In the first of these papers the information available on the varieties is summarized in a series of tables for the benefit of the general reader. The second paper, which appears as Appendix I, contains the detailed notes from which the tables were derived, and it is hoped that these notes will enable those who are specially interested in this work to assess more accurately the potentialities of these new seedlings. The report also includes a paper on progress in polyploid hop breeding by R. A. Neve and R. F. Farrar. While much of this paper may be too technical for many readers, the later sections of it on the commercial promise of this work and on the results already achieved, will be found to be of general interest to all who are concerned with the hop industry.

Studies on plant nutrition have been confined mainly to the assessment of results obtained during the preceding three years. This research falls into two classes:

- (a) The effect of soil pH and soil type on the mineral uptake of the hop plant at different nutritional levels.
- (b) The boron nutrition of the hop plant.

This work is being written up for publication in the near future.

Research on *Verticillium* wilt disease and on hop virus diseases has remained the responsibility of the Plant Pathology Section of East Malling Research Station and is dealt with in the reports

issued by that body. Wye has worked in close liaison with East Malling and the joint scheme for the production of wilt tolerant varieties continues to make satisfactory progress. It should be emphasized, however, that at least ten years must elapse before any proven varieties which may be produced by this scheme are freely available to growers.

In June, at the request of the Agricultural Improvement Council, a Hops Working Party was formed to advise on the design and management of field experiments. The Department of Hop Research is represented on this Working Party by Mr. Darling (who acts as chairman) and by Mr. Thompson; and through this channel Wye is linked with the hop research at Rosemaund Experimental Husbandry Farm in the West Midlands. This link is strengthened by the fact that Mr. Darling is now a member of the Rosemaund Farm Advisory Committee. A review is given elsewhere in this report of the hop experiments at Rosemaund which is published by permission of the National Agricultural Advisory Service of the Ministry of Agriculture.

In July Mr. Darling and Mr. Thompson attended a conference of the Scientific Commission of the European Hops Cultivation Committee as delegates from Great Britain. This conference was held at Zalec, near Ljubljana, in northern Yugoslavia. Papers were read by various delegates on problems of mutual interest and Mr. Thompson contributed a paper on mineral deficiencies in the hop plant. Messrs. Darling and Thompson subsequently attended the full session of the European Hop Cultivation Committee which took place in London in August and at which the report of the Scientific Commission was received and adopted. In July, 1955, the Scientific Commission is to meet at Wye under the presidency of Mr. Thompson. A review of hop research overseas, prepared by Mr. Thompson, is given elsewhere in this report.

The Department has maintained close contact with the Hops Marketing Board, the Institute of Brewing and the Association of Growers of the New Varieties of Hops. Department staff have attended meetings of appropriate committees of these bodies during the year and help received from them is gratefully acknowledged.

The Department has profited by close association with the Brewing Industry Research Foundation throughout the year. The Foundation has carried out small-scale brewing trials on samples of dried hops from plant breeding and drying experiments. Data from these trials have been of great help in enabling the staff at

Wye to assess the results of their work, and the opportunity is taken to express thanks for this assistance. In May, Mr. Darling and Mr. Thompson attended a research colloquium at Nutfield on hop chemistry, organized by the Foundation, in which recent advances in the chemistry of the soft resins were the subjects of several papers and of much helpful discussion.

The Department has also co-operated closely with the National Agricultural Advisory Service of the Ministry of Agriculture and Fisheries and is much indebted to Dr. H. H. Glasscock, Advisory Plant Pathologist, N.A.A.S., South East Province, for help in the identification of hop diseases and for advice on their control.

No machine-picking surveys were organized by the Department in 1954. The findings of past surveys have been summarized in an article written jointly by Mr. G. P. Chater and Miss C. L. Jary, respectively N.A.A.S. Hops Advisory Officers for the West Midlands and the South East Provinces, which has just been published as a separate paper by Wye College. Machine-picking is now firmly established as a commercial practice and the time has come for research on this part of the hop industry to be undertaken by agricultural engineers. An approach by Wye College to the National Institute of Agricultural Engineering has been sympathetically received and the Institute is exploring the possibility of co-operating with Wye in this field of research.

ACKNOWLEDGMENTS

Thanks are due to Messrs. Arthur Guinness, Son and Co. Ltd., who have allowed the Department extensive facilities for field experimentation on their Bodiam hop farms, and to Mr. A. J. Large, Cherry Gardens, Goudhurst, for accommodating a series of manurial deficiency plots on his land. The help of Captain A. O. R. Beale, Castle Farm, Sissinghurst, and Mr. E. E. Taylor, Maplescombe, in maintaining observation trials of the Wye Varieties is gladly acknowledged.

Grateful mention must be made of the help given by Mr. L. Fletcher, of William Younger and Co. Ltd., Abbey and Holyrood Breweries, Edinburgh, in carrying out commercial valuations with hops from Professor Salmon's plant breeding plots. In this connection, sincere thanks are also due to Lieutenant-Colonel F. N. Richardson and Mr. A. E. Quin, of Wigan, Richardson and Co., 15 Southwark Street, London, S.E.1, for examining and appraising samples of dried hops from experiments at Wye. This help from

commercial sources is of the greatest value, since it provides guidance that is vitally important and which can be obtained from nowhere else.

Finally, thanks are due to Mr. Arthur Amos, Spring Grove, Wye, to Professor T. Wallace, Long Ashton, Bristol, and to Dr. A. H. Burgess, late Head of this Department, for friendly counsel given throughout the year.

H. S. DARLING

PLANT BREEDING SECTION

REVIEW OF THE YEAR'S WORK

R. A. NEVE and R. F. FARRAR,
with report by PROFESSOR E. S. SALMON

GENERAL

The reorganization of the nursery garden which is being carried out over a three-year period was started in the autumn of 1953, and has inevitably caused a great deal of extra work for this section, as well as for the field staff.

In both 1953 and 1954 it has involved taking and potting some 1,000 cuttings from the parts of the garden about to be grubbed, and replanting these in new positions the following year. The parentage of all the material thus saved has been traced back, and replanting carried out in groups of similar parentage.

The principal advantage to be gained from the new organization is that seedling families are now planted in seedling rows instead of being scattered through the garden, and will remain without any grubbing for three years. This will allow a far clearer picture to be obtained of the characters of each family, thereby facilitating the work of progeny testing male hops used for breeding. This season, twelve seedling families (together with two raised by Professor Salmon) were thus planted out as complete units.

These families, while still in the seedling stage in the glass house, were heavily attacked by downy mildew, and, in all, over 40 per cent. were killed. As soon as the infection was observed, all the polyploid seedlings were removed to a fresh section of the glass-house, and losses were considerably fewer than with the diploid families, in which the first affected seedlings were found. Such an attack has only been known to occur once before and then on a much smaller scale. It is regrettable that the families, some of which were in any case small, should have been still further reduced. There is not even any certainty that the seedlings lost were those most susceptible to downy mildew, since the degree of infection was not necessarily uniform throughout the house.

It is evident that much more attention will have to be paid to the question of susceptibility of new varieties to downy mildew, and during the year material of three varieties said to be resistant to the disease were obtained from Dr. Zattler of Munich.

Although records of the incidence of downy mildew on new varieties under field conditions have been kept for some time, these are of little value, since all varieties have not been subjected to a uniform level of infection. With the granting of approval for the appointment of a pathologist in 1955, there are prospects of our being able to start a vigorous campaign of breeding for resistance to this very costly disease.

VERTICILLIUM WILT TOLERANCE

Wye/E.M.R.S. Joint Scheme

The Wye/East Malling Research Station joint breeding project has now reached a stage where the number of varieties has been substantially reduced, and the available material of each variety increased to a level which allows more thorough testing from both wilt and cultural aspects.

At the beginning of the year, 170 selections remained in the scheme at Wye. Plots in Wye Field became vacant in the spring, and in them hills of these varieties were planted out for cultural observation. In most cases there was only a single hill of each variety, in some there was room for two hills. It is intended that as the number of varieties is reduced, clonal stocks of the remainder will be built up in these plots.

As a result of the cultural observations during the year, a few varieties showing no commercial promise were discarded.

During the season, 99 selections were tested for wilt tolerance at East Malling in a 5-plant subsidiary test, and many were discarded. A further six were tested in a 30-plant final test using OM26 and OR55 as standards of tolerance, OM26 being the most highly tolerant variety known. Three of the selections proved to be at least as tolerant as OM26, two reached the level of OR55, while one was more susceptible than OR55, and has been discarded.

The total number of discards for 1954 for all reasons, was 64, leaving 106 varieties in the scheme at Wye for further selection during 1955. Of these 106 varieties, 54 will be sent to East Malling for 30-plant final tests, and 21 for 5-plant subsidiary tests, during the summer of 1955.

In addition to the material at Wye, there are nine varieties undergoing propagation at East Malling. These varieties came through the 1-plant test in 1952, but the basic stock at Wye failed to survive. These have not been included in the totals previously mentioned in this report, as they do not form part of the wilt-free stock maintained at Wye.

By the end of 1957, all varieties remaining in the scheme should have had their 30-plant final test, and this phase of the programme will then be complete. The 30-plant final test is being used to decide the level of tolerance of any variety, whereas the 1- and 3-plant tests used in 1952 and 1953, and the 5-plant tests now being used, are merely to eliminate the highly susceptible varieties as soon as possible, and thereby save unnecessary propagation.

Nonsuch (OB53) × wilt-tolerant males

The three crosses made in 1952 between Nonsuch (OB53) and three wilt-tolerant males, produced 98 seedlings, of which 20 proved to be males.

These male seedlings will be submitted to wilt tests as soon as practicable, the aim being to select, if possible, more highly tolerant males than those already being used.

One of the three crosses yielded very few seeds and this cross was repeated in 1953. Although a good collection of seed was made, and germination in 1954 was satisfactory, many seedlings were lost due to the attack of downy mildew in the glasshouse mentioned previously. Eventually thirty-five seedlings were planted out and some have proved to be males, but many plants were too immature to flower, and their sex will not be determined until the 1955 flowering period.

The female seedlings in these families will be recorded from a commercial and cultural aspect, and any promising ones will subsequently be submitted to wilt test.

Tetraploid Bullion × wilt-tolerant males

Seed collected from six crosses made in 1953 between tetraploid Bullion and six diploid wilt-tolerant males was sown in the spring. Germination was not very good, and some losses were caused by the attack of downy mildew in the glasshouse.

Random samples of twenty seeds each were taken from the six collections, and sown in miniature soil blocks at the same time

as the bulk sowings. After germination these were checked for polyploidy, which was confirmed; the check also indicating that the tetraploid parent material was being maintained.

All surviving seedlings were planted out in the Nursery Garden in the summer, a total of two hundred seedlings finally resulting from the six families.

These seedlings will be submitted to a wilt test at East Malling, as soon as practicable, the trial to serve as a progeny test on the male parents, and as a preliminary screening of the commercially promising female seedlings.

The aim of these six crosses using wilt-tolerant males has been to attempt to combine tolerance with Bullion characteristics. Any commercially promising seedlings which may show tolerance, will also provide indications of the measure of success that may be expected from similar crosses using tetraploid English females, planned for 1955.

POLYPLOID HOPS

A review of the more interesting scientific results obtained from the work on polyploidy appears elsewhere in this report.

Observations on the oldest triploid material, the open pollinated seedlings of Bullion and Brewer's Gold, were continued. These plants were, on the whole, extremely vigorous, and except on the highest wirework and the widest spacing this resulted in their being very "housed in". Possibly for this reason the crop appeared lighter, and the cones were very much smaller, than in previous years. Analysis showed that resin content was virtually the same as in previous seasons. Three young seedlings of Brewer's Gold had outstandingly high resin contents as follows:

WFV 17:	12.93	per cent.	alpha resin
WFV 19:	11.43	"	" "
WFV 20:	11.19	"	" "

WFV 20 was included in a group of samples examined by Messrs. Wigan, Richardson, and was remarkable in that it showed practically none of the American aroma normally found in these varieties. All the triploids of Bullion examined at the same time showed close resemblance to the parent variety, although there were minor differences between them. Most of the samples were far inferior to those of 1953, having evidently been picked too early in a very late season.

An unpublished report received from the Brewing Industry Research Foundation on the results of small-scale brewing with triploids of the 1953 crop is most interesting. Ten triploid seedlings of Bullion were compared with the parent variety. Seven of these were preferred to Bullion, one was found very similar, one was described as "stronger than Bullion", and one as "unacceptable—harsh unpleasant flavour". The comment on most of the seedlings was that they did not produce the harsh lingering after-taste found with the Bullion variety.

Two triploid seedlings of Brewer's Gold were compared, one was found to have an "acceptable pleasant normal hop flavour", the other was "unpleasant with strong after-taste and coarse foreign flavour".

While too much emphasis should not be placed on the results of a single small-scale trial as regards individual varieties, there seems to be little doubt that triploid seedlings can be expected to compare favourably with their female parent.

One seedling included in this trial had a very powerful and unpleasant garlic aroma, both in the field and in the dried sample. In the brewing trial it was described as having "a strong but well balanced hop flavour but very close to the parent Bullion". It is evident that the garlic aroma does not persist into the beer sample, though the variety would be rejected by the trade because of its unpleasant aroma.

One triploid seedling of Nonsuch (OB53) has been raised and it yielded a sample this season. This was found on analysis to contain 11.78 per cent. alpha resin, and was thought at Wye to have a very pleasant aroma. However, the sample sent to Messrs Wigan, Richardson had such a poor rub that it was impossible to detect the real aroma.

It is evident that triploid seedlings of Bullion and Brewer's Gold will mostly fall in the same class as these parents, for which there is only a limited demand in the trade. Efforts are, therefore, being concentrated on the production of triploid varieties from Goldings and Fuggles.

A cross was made in 1953 between tetraploid Eastwell Golding and the diploid male hop OB21. Only a small cutting of the Golding parent was available, and only a few seeds were obtained. Of the four seedlings which resulted, two were triploids, one tetraploid, and one aneuploid with 31 chromosomes. In addition, twenty-four triploid seedlings from open pollinated Eastwell Golding were planted out, and these should produce a crop in 1955.

The original colchicine treatment of Fuggle plants in 1950 was largely unsuccessful, and this year a further attempt was made. Indications so far are that this has been highly successful, and seventeen seeds were obtained from the treated material. Provided chromosome counts next spring confirm the preliminary results, it will be possible to use this treated material for large-scale pollinations in 1955, using wilt-tolerant males.

Colchicine treatment was also carried out on two male varieties of English origin to provide material for studying the cytology of polyploid hops, and the effect of polyploidy on sex ratios.

RESIN GLANDS ON ANTHERS

The four families mentioned in last year's report were raised and planted out. It is hoped that these families will next season provide useful information on a possible correlation between the resin content of the female and the number of resin glands per anther of the male hops.

REPORT BY PROFESSOR E. S. SALMON

Samples of twenty-two new seedlings, of various parentages, were collected and dried and submitted to a brewer for evaluation on aroma and commercial promise. Chemical analyses were made by Mr. E. W. Weston, B.Sc.; several of the seedlings gave high percentages of soft resins, with one over 9 per cent., three over 8 per cent., two over 7 per cent., and four over 6 per cent. alpha resin. Favourable reports as to aroma were received. As noted in the Annual Report for 1953, p. 43, it is being found possible to breed seedlings of a class "Very Early" or "August" hops; should these prove to be of commercial value, they will be much in demand for machine-picking.

Growths of twenty-nine seedling varieties were dried separately and distributed to two firms of brewers for evaluation and brewing trials.

Of the twenty seedlings supplied to East Malling Research Station for *Verticillium* tolerance trials in 1954, none showed sufficient tolerance to be of commercial promise; one (R4/103) showed 43.4 per cent. of wilt, while others gave a considerably higher percentage, many being 100 per cent. susceptible.

Field trials of the new wilt-tolerant seedling OZ97a, reported from the wilt tolerance trials at East Malling Research Station in 1953, have been arranged on two farms in Kent.

In response to numerous applications, small stocks of 25 or 50 rooted sets of Bramling Cross (OT48) have been supplied to twenty-two growers in Kent with *Verticillium*-infected soil, and to one grower in Sussex. In most cases these sets are being used for propagation by layering.

COMMERCIAL GROWTH OF NEW VARIETIES

The production of New Varieties showed an increase of 1,053 pockets in 1954. The following information on the crop marketed by registered producers in 1953 and 1954, and the acreage in June, 1954, of the New Varieties, has been supplied by the Hops Marketing Board.

(1) CROP

1953	6,140 pockets	approx.	9,210 cwt.
1954	7,193 „	„	10,789 „

The 7,193 pockets marketed in 1954 consisted mainly of Keyworth's Midseason (OR55), 3,511 pockets; Brewer's Gold (C9a), 965 pockets; Bullion (Q43), 686 pockets; Early Promise (X35), 576 pockets; Northern Brewer (WFB135), 444 pockets; Keyworth's Early (OJ47), 293 pockets; Pride of Kent (170a), 121 pockets; Quality (OO63), 116 pockets; Sunshine (V94), 103 pockets. Small amounts of the following varieties were grown: Malling Midseason (BB28); John Ford (WFA90); Norton Court Golding (WFG19); Concord (OH44); Brewer's Standby (HH44); Early Choice (FF21); College Cluster (N15bis); Bramling Cross (OT48); C2 (E.M.R.S.); OF27.

(2) ACREAGE (IN PLANT, JUNE, 1954)

Class 1: intolerant (susceptible) to Verticillium Wilt

Variety	Acres
Brewer's Gold (C9a)	195.2
Bullion (Q43)	158.4
Northern Brewer (WFB135)	87.0
Early Promise (X35)	68.9
Sunshine (V94)	17.2
Pride of Kent (170a)	15.9
Quality (OO63)	10.1
John Ford (WFA90)	6.6

<i>Variety</i>	<i>Acres</i>
Concord (OH44)	6.3
Brewer's Favourite (OP21)	5.7
College Cluster (N15 <i>bis</i>)	5.6
Brewer's Standby (HH44)	5.0
Malling Midseason (BB28)	4.5
Early Choice (FF21)	3.6
OF27	2.2
Norton Court Golding (WFG19)	1.4
AGG8	1.0
Copper Hop (OK40)	0.2
ON78	0.2
OQ14	0.2
OYO17	0.1
WFH16	0.1
Unspecified Varieties	25.6
Total	621.0

Class 2: tolerant (resistant) to Verticillium Wilt

<i>Variety</i>	<i>Acres</i>
Keyworth's Midseason (OR55)	566.4
1147	99.1
Keyworth's Early (OJ47)	46.7
Bramling Cross (OT48)	9.2
C2 (East Malling Research Station)	4.0
D1 (E.M.R.S.)	1.5
J2 (E.M.R.S.)	1.4
D3 (E.M.R.S.)	0.1
	728.4
Grand total	1,349.4

SOME NEW VARIETIES OF HOPS IN WYE FIELD PLOTS, WYE COLLEGE

F. H. BEARD and E. S. SALMON

In 1950 the trials of new varieties of hops (instituted in 1917) at East Malling Research Station were discontinued; thirty-three reports on these trials have been published (1). A certain number of new varieties, the characteristics of which had not been fully ascertained at East Malling, were transferred to trial plots in Wye Field Hop Garden at Wye College. Nineteen of these varieties are discussed in the present article, together with fourteen additional new seedlings.

The "plant" in the Wye Field variety plots is 6 ft. square with umbrella type wirework 12 ft. 9 in. high. The plots consist mainly of 40 hills each. Originally the standard umbrella stringing was employed, but this was later changed to upright umbrella (in which the strings from adjacent hills do not cross each other) to reduce the risk of "housing" with the rather close "plant". However, with the very vigorous new varieties such as those derived from the wild Manitoba hop, even when grown with only one bine per string, conditions are still too cramped to allow for their full potential development. There is therefore a tendency for the cropping of these very vigorous seedlings to be reduced while the risk of downy mildew attack is increased.

The 33 new varieties discussed in the article may be grouped into four main lines of descent as follows:

1. Eight descendants from an original cross between Canterbury Golding and male OB21; this male being derived from the variety Brewer's Gold (C9a) introduced Manitoba genes. These eight varieties comprise five seedlings of the first generation (which also includes the named varieties John Ford (WFA90), Northern Brewer (WFB135), and Wye Field Golding (WFC81)), and three seedlings of the second generation by open pollination at Wye; two from Wye Field Golding and one from John Ford.

2. Eighteen descendants from the wild Manitoba hop, BB1, by open pollination at Wye. This group comprises:
 - (a) seven seedlings of the first generation (which also includes the named varieties Bullion (Q43) and Brewer's Gold (C9a));
 - (b) six seedlings of the second generation, three from seedling R3/100, two from Bullion and one from Brewer's Gold. (This second generation also includes the named variety Nonsuch (OB53));
 - (c) five seedlings of the third generation: two from progeny of Brewer's Gold, two from progeny of Bullion and one from Nonsuch.
3. Three descendants of the American variety Oregon Cluster by open pollination at Wye, two being of the third generation and one of the fourth.
4. Four descendants of *Humulus americanus* var. *neomexicanus* by open pollination at Wye. One of these is of the second generation and three are of the third.

Information on each variety is given under the following headings:

- (a) Yield in cwts. of dried hops per acre.
- (b) Physical (organoleptic) examination: commercial appraisal of the appearance and aroma of the dried sample.
- (c) Chemical analysis for soft resin content (preservative value).
- (d) Cultural details.
- (e) Susceptibility to downy mildew disease and mould disease.

Here it should be noted that too much reliance must not be placed on the information given on cone infection by downy mildew as its incidence may be influenced by such factors as amount of bine growth, stage of growth when sprays are applied, and time of picking. In a garden containing varieties of all seasons it is impossible to apply sprays at the optimum time for each. Rootstock infection is assessed on the number of hills replanted or recorded as weak, downy mildew being the commonest cause of dead and weak hills.

TABLE 1
CANTERBURY GOLDING × OB21 (SEEDLING OF BREWER'S GOLD)—FIRST GENERATION

Variety and plot number	(a) Mean yield per acre in dried cwts.	(b) Physical examination	(c) Mean resin analysis % alpha % beta	(d) Cultural details	(e) Downy mildew and mould diseases
WFI36 (1)	20·81 (5)	Pleasant, non-American aroma	6·72 11·03 (4)	Early growth weak, but lateral growth good. Mid- season-Late	Moderately liable to spikes; evidence of rootstock infection by downy mildew
WFD20 (15, 28)	24·18 (5)	Pleasant English aroma, with occasional slight tendency to coarseness	6·31 10·51 (5)	Vigorous; tendency to- ward leafy cones. Mid- season	Only slightly liable to spikes; no rootstock infection by downy mildew
WFA53. (18)	20·33 (6)	Pleasant English type aroma	4·92 8·60 (4)	Moderate vigour; tenden- cy toward leafy cones. Early Midseason	Very liable to spikes; no root- stock infection by downy mildew
WFI66 (37)	23·64 (3)	Pleasant aroma	5·27 10·92 (2)	Vigorous; tendency to- ward leafy cones. Late	Moderately liable to spikes; no rootstock infection by downy mildew. Susceptible to mould
WFH6 (10)	18·91 (1)	Pleasant aroma	5·18 10·53 (1)	Plot immature; planted 1951-52	Appears to be moderately liable to spikes

TABLE 2
SECOND GENERATION FROM CANTERBURY GOLDING
(A) via Wye Field Golding (WFC81) (B) via John Ford (WFA90)

Variety and plot number	(a)	(b)	(c)	(d)	(e)
OQ14 (A) (8)	21.35 (3)	Aroma very good; Golding type. Very good appearance	6.83 11.34 (2)	Late in starting growth, but very vigorous. Mid-season-Late	Only slightly liable to spikes; no rootstock infection by downy mildew
WFI94 (A) (14)	19.36 (5)	Pleasant mild English aroma. Good appearance	5.42 11.69 (3)	Fairly vigorous; tendency toward leafy cones. Mid-season	Very liable to spikes; liable to rootstock infection by downy mildew
WFF90 (B) (25)	19.38 (2)	Pleasant aroma. Very good appearance, bright colour	7.22 9.18 (2)	Fine, close-jointed bine, little head, crops well down bine. Early Mid-season or Midseason	Particularly liable to lateral spikes; no liability to rootstock infection by downy mildew

TABLE 3
FIRST GENERATION FROM WILD HOP, MANITOBA (BB1)

Variety and plot number	(a)	(b)	(c)	(d)	(e)
OQ22 (6)	22-42 (1) 24-24* (15)	Good, not strong. aroma. Fine side	6-56 12-64 (7)	Similar to Bullion (Q43) in general habit. Late	Very low incidence of spikes; may suffer from rootstock infection by downy mildew
OW76 (13)	21-61 (1) 20-53* (13)	Manitoba aroma. Very good appearance	7-35 9-90 (3)	Ditto. Midseason	Low incidence of spikes, no evidence of rootstock infection by downy mildew
OO21 (58)	21-33* (10)		6-20 11-95 (4)	Ditto, but cones smaller. Late	Low incidence of spikes, but perhaps slightly greater than OQ22 and OW76 above. No rootstock infection by downy mildew
OV80 (66)	25-39 (1) 19-67* (12)	Aroma pleasant, but has a slightly rank background. Appearance good	6-13 11-31 (5)	Ditto., with large cones. Midseason	Low incidence of spikes; no rootstock infection by downy mildew
FF8 (72)	25-48 (1) 22-32* (11)	Slightly rank aroma. Not unpleasing appearance	5-78 10-04 (4)	Ditto, with large cones. Late	Rather more subject to spikes than others in this group; no evidence of rootstock infection by downy mildew
RI/38a (76)	22-66 (2) 18-36* (6)	Pleasant American aroma. Appearance good	5-03 7-80 (1)	Similar to Bullion (Q43) in general habit. Tendency for growth to be "biny". Late	Low incidence of spikes; no evidence of rootstock infection by downy mildew
OX88 (81)	19-11* (13)		4-30 11-93 (4)	Ditto, well developed cones. Late	Low incidence of spikes; liable to slight downy mildew infection of rootstock

* First Mating data.

TABLE 4

SECOND GENERATION FROM WILD HOP, MANITOBA

(A) via Bullion (Q43). (B) via R3/100. (C) via Brewer's Gold (C9a).

Variety and plot number	(a)	(b)	(c)	(d)	(e)
WHG66 (A) (7)	22.66 (2)	Pleasant English aroma. Very good appearance	7.15 14.71 (2)	Very vigorous; needs high wirework and wide spacing. Late	Very low incidence of spikes. No evidence of rootstock infection by downy mildew
WFH65 (A) (61)	25.75 (3)	Fresh, slightly fruity aroma with trace of American. Good appearance	7.54 12.38 (1)	Moderate vigour; little head but long ropes of hops; cones pale green. Midseason—Late	Low incidence of spikes and no evidence of rootstock infection by downy mildew
QH77 (B) (21)	23.82 (1) 22.22* (8)	Aroma unusual, but not unpleasant	6.64 10.59 (5)	Vigorous, requires ample room on good soils. Late	Moderate—light incidence of spikes and no evidence of rootstock infection by downy mildew
OD18 (B) (63)	24.67 (2) 15.13* (8)	Aroma pleasant; possibly a trace of American	4.80 13.83 (3)	Did poorly on light Malling loam. Midseason	Very subject to spikes, but no evidence of rootstock infection by downy mildew
OR38 (B) (64)	22.50 (2) 15.58* (5)	Good appearance, but coarse aroma	3.86 10.38 (2)	As above	Very low incidence of spikes, and no evidence of rootstock infection by downy mildew
OT9 (C) (67)	23.50 (3) 15.09* (4)	Aroma pleasant with faint suggestion of American	6.89 10.07 (4)	As above. Midseason—Late	Little subject to basal spikes, but liable to have many lateral spikes in some years. Rootstock may be damaged by downy mildew

* East Malling data.

TABLE 5

THIRD GENERATION FROM WILD HOP, MANITOBA

(A) via Bullion (Q43) and WFC79. (B) via Brewer's Gold (C9a) and III49. (C) via 334a and Nonsuch (OB53).

Variety and plot number	(a)	(b)	(c)	(d)	(e)
WFH16 (A) (34)	17.94 (6)	Pleasant, non-American aroma. Good appearance and colour	5.89 9.70 (5)	A very early variety making only moderate growth. Cones small, but many-petalled	Almost entirely free from spikes and no evidence of rootstock infection by downy mildew
WFJ53 (A) (44)	25.25 (2)	Pleasant American aroma. Very good appearance	6.60 9.04 (3)	The vigorous and stiff vines make training difficult. Cones large, long and dense. Late	High incidence of spikes, together with infection of rootstock by downy mildew
WFB117 (B) (39)	21.31 (5)	Pleasant American aroma	5.17 10.62 (3)	Produces ample bine at training; nice pale cones. Midseason-Late	Low incidence of spikes and no evidence of rootstock infection by downy mildew
WFD82 (B) (41)	22.28 (4)	Pleasant American aroma	4.75 11.55 (2)	Produces ample bine at training; cones small, but dense. Midseason	Moderate to high incidence of spikes; no evidence of rootstock infection by downy mildew
WFD88 (C) (32)	23.18 (2)	Pleasant mild American aroma. Good appearance	6.46 10.68 (3)	Bines crop well down, but cones borne rather singly. Midseason	Moderate incidence of spikes, but no evidence of rootstock infection

TABLE 6

THIRD GENERATION FROM OREGON CLUSTER (via M45 and OP13)

Variety and plot number	(a)	(b)	(c)	(d)	(e)
L11 (48)	21.33 (1) 17.15* (12)	Pleasant, possibly faint American aroma	5.60 10.87 (3)	Moderate vigour; large, many petalled cones. Late. Prefers Wye brickearth to Malling light loam	Usually free from basal spikes but has had many lateral spikes in some seasons; some evidence of rootstock infection by downy mildew
CC77 (71)	27.01 (2) 15.76* (11)	New fragrant aroma with coarse background	6.38 9.60 (6)	Prefers the Wye loam to Malling light loam. Cones of good colour and silky in texture. Late	Almost entirely free from spikes; no indication of rootstock infection. Cones may also resist infection by downy mildew

TABLE 7

FOURTH GENERATION FROM OREGON CLUSTER (via M45, OP13 and L11)

Variety and plot number	(a)	(b)	(c)	(d)	(e)
ADD50 (62)	24.19 (2) 15.35* (7)	Pleasant, non-American aroma. Good appearance, pale colour	5.66 10.88 (4)	Prefers Wye brickearth to Malling light loam. Late	Basal spikes not usually numerous, but lateral spikes plentiful in some seasons; no evidence of downy mildew in rootstock

* East Malling data.

TABLE 8

SECOND GENERATION FROM *H. americanus* VAR. *neomexicanus* (via Y90)

Variety and plot number	(a)	(b)	(c)	(d)	(e)
R4/40a (77A)	23.77 (1) 19.23* (11)	Strong (blackcurrant) aroma	5.36 8.71 (3)	Crops well down bine; cones clustered and many petalled. Midseason-Late	Very free from spikes and no evidence of downy mildew in rootstock

TABLE 9

THIRD GENERATION FROM NEOMEXICANUS
(A) via Y90 and R1/94. (B) via Y90 and EE92.

Variety and plot number	(a)	(b)	(c)	(d)	(e)
AOR43 (A) (46)	19.63 (2)	Strong American aroma. Good appearance	7.93 10.11 (2)	Crops well down bine; many-petalled dense cones. Late	Only moderate incidence of spikes and no evidence of downy mildew infection of the rootstock
AOS14 (A) (84)	22.71 (1) 15.48* (7)	Pleasant "Manitoba" aroma. Very good appearance	4.31 13.58 (2)	Crops well down bine; long compact cones, in dense heads. Early-Midseason. Did poorly on Malling light loam	Has produced many spikes but no evidence of downy mildew infection of rootstock
OL53 (B) (75)	25.21 (3) 22.22* (10)	Pleasant aroma. Very good appearance	5.59 7.90 (2)	Cones large, many-petalled and primrose colour throughout. Midseason	Very liable to both spikes and cone infection; no evidence of downy mildew infection of rootstock

* East Malling data.

Data for the 33 varieties are summarized in Tables 1 to 9 given above. Full details for each variety are given later in Appendix I to this report (2). In this appendix reference is also made to the newly identified compound cohumulone which is present in unusually large amounts in the resin of Brewer's Gold and Bullion, and which possibly may occur in a like degree in related varieties. In the tables the data on mean yield and mean resin content are accompanied by numbers in brackets which indicate the number of seasons from which the average is derived. In some cases yield data from East Malling are given in the tables and are indicated as such. Otherwise the data in the tables derive from experience in Wye Field.

REFERENCES

- (1) SALMON, E. S. Reports on the trial of New Varieties of hops at East Malling Research Station. Nos. 1-33 (1918-1949).
- (2) BEARD, F. H. and SALMON, E. S. Detailed notes on some new varieties of hops in Wye Field Plots, Wye College. *Rep. Dept. Hop Res. Wye Coll. for 1954*. Appendix I. p. 97.

PROGRESS IN POLYPLOID HOP BREEDING

R. A. NEVE and R. F. FARRAR

SUMMARY

1. Attempts to isolate wholly tetraploid material from colchicine treated plants of the varieties Brewer's Gold and Bullion appear to have been successful. In the case of the variety Eastwell Golding, some plants which were largely tetraploid in one year were found to be mainly diploid in the next.

2. The results of four different colchicine treatments are compared. A concentration of 0.75 per cent. was more effective than one of 0.5 per cent.

3. Seedlings raised from colchicine treated material have usually been either diploid or triploid. A few pentaploid, aneuploid and tetraploid seedlings were also discovered. The mode of origin of the tetraploids is discussed.

4. The sex ratios of triploid seedlings show no marked difference from those of diploids.

5. The commercial qualities of triploid seedlings are considered with special reference to their resemblance to their female parent, the seed content of their hops, and their vigour.

6. The value of polyploidy in hop breeding is discussed in the light of experience with these triploids.

INTRODUCTION

A programme of polyploid hop breeding at Wye College was started in 1950, in an endeavour to produce seedlings combining new and desirable qualities, with a marked similarity to accepted commercial varieties.

The breeding of normal diploid hops, using commercial female parents, produces a very wide range of types, most of which are quite unacceptable to the trade.

This programme was initiated by Dark, and its purpose, technique and early results have been described by him in this report for 1952 (1953).

Work on his material has been continued, and fresh material raised. This can conveniently be considered under two headings: (A) colchicine treated material of established varieties, and (B) seedlings raised from this.

A. COLCHICINE TREATED MATERIAL

Tetraploid hops are of value in the breeding programme merely as a necessary step in the production of triploid seedlings. Attention has, therefore, been concentrated on the value of different colchicine treatments for the production of tetraploid tissue, and the problem of isolating wholly tetraploid plants from the chimaerical tissue normally resulting from this treatment.

(1) ISOLATION OF TETRAPLOID MATERIAL

The varieties Bullion and Brewer's Gold were treated with colchicine in 1950 as described by Dark. Treated buds grew into laterals which were struck and then layered, the layered bine being cut up at the end of the season to provide a number of cuttings.

These cuttings were grown on, and are now mature hills. Seed was collected from some of them in 1951, germinated in 1952, and the seedling root tips examined to establish their chromosome number. In 1952 and 1953, seed collections and basal cuttings were taken from selected bines. The term "bine-seed collection" was adopted to indicate the yield from one bine which was itself represented by a basal cutting. If a bine yielded triploid seedlings the cutting was retained; if only diploid seedlings were obtained the cutting was discarded.

By such methods it was hoped to isolate material which was wholly tetraploid. This has apparently been achieved, and at the same time the results from season to season have given some indication of the balance between diploid and tetraploid tissue present in a chimaerical hill.

Time has allowed only a few plants to be studied, namely:

C3D, C4A and C4B, from Brewer's Gold.

C7A, C7B, C7G, C8A and C8G, from Bullion.

In each variety, two plants were selected for study, because, although they had originated as adjacent cuttings from the same colchicine treated lateral, one of each pair proved to be mainly diploid, and the other mainly tetraploid. The relationship between these pairs is indicated by their numbers, C4A and C4B being one pair, C7A and C7B the other.

The results obtained are set out in Table 1. Bines are numbered Bine 1, Bine 2, etc., suffixed by the year in which the basal cutting was taken. Thus, C3D Bine 1 (52) was a cutting taken from the hill C3D in 1952, and C3D Bine 1 (53) a different cutting from the same hill in the following season.

Since no tetraploid male plants are known to exist in the gardens, it is assumed that all pollination has been by diploid males. Diploid females would thus be expected to yield diploid seedlings, tetraploid females yield triploid seedlings, and octaploid females yield pentaploid seedlings.

It will be noted that some tetraploid seedlings have been recorded. This fact is discussed later, and for the purposes of this section it is assumed that they have arisen from tetraploid female tissue.

The main points of interest shown by the results are:

(a) There has been no marked competition between diploid and tetraploid tissue resulting in the elimination of the one or the other. Thus, in the case of C3D, tetraploid cells were found in the root tips in 1951, and both diploid and tetraploid cells in the young leaves. Three bine-seed collections were made in 1952, two of which gave all triploid seedlings, the other all diploid. Four bine-seed collections were made in 1953, three of which gave triploid seedlings, while the fourth gave diploids. This indicates that the proportion of diploid to tetraploid tissue in the hill had not greatly changed.

(b) It appears that non-chimaerical tissue can be fairly readily isolated from a chimaerical plant by taking basal cuttings. Of the eight plants under investigation, C3D, C4A, C7A and C8G have been shown, from the ploidy of their seedlings, to be chimaerical. Of the seventeen basal cuttings taken from these four plants, only three have so far been shown to be chimaerical.

The variety Eastwell Golding was colchicine treated in 1951, but in this case the struck laterals were not layered. In 1952 seed collections were made from the resulting plants, but were taken from the whole plant and not bine by bine. Cuttings were taken the same year, but since there were no bine-seed collections to correspond with them, they were labelled /A, /B, /C, etc. In 1953, these cuttings were grown on, and seed was collected from them; bine-seed collections and their corresponding basal cuttings were also taken from the original hill. Root tips of the seedlings arising from these various seed collections were examined, with the results shown in Table 2, and it will be seen that they are in striking contrast to those obtained from Brewer's Gold and Bullion.

TABLE 1
RESULTS OF COLCHICINE TREATMENT OF THE VARIETIES BREWER'S GOLD AND BULLION

Hill No.	1951		Seedlings, 1952	Basal cutting No.	Seedlings		Basal cutting No.	Seedlings, 1954
	Root tips	Stomata			1953	1954		
C3D (Brewer's Gold) ..	4x	Normal	3x	Bine 1 (52) Bine 2 (52) Bine 3 (52)	3x 2x 3x	3x — 3x	Bine 1 (53) Bine 2 (53) Bine 3 (53) Bine 4 (53)	3x 2x 3x 3x
C4A (Brewer's Gold) ..	2x and 4x	Giant	—				Bine 1 (53) Bine 2 (53) Bine 3 (53) Bine 4 (53)	3x, 4x and 5x 2x and 3x 3x 3x
C4B (Brewer's Gold) ..	2x	Normal	—				Bine 1 (53)	2x
C7A (Bullion) ..	—	Giant	2x				Bine 1 (53) Bine 2 (53) Bine 3 (53)	2x 2x and 3x 2x
C7B (Bullion) ..	—	Giant	3x	Bine 1 (52) Bine 2 (52)	3x 3x	(1/A) 3x 3x	Bine 1 (53) Bine 2 (53)	3x 3x
C7G (Bullion) ..	4x	Giant	3x	Bine 1 (52) Bine 2 (52) Bine 3 (52)	3x 3x 3x	— 3x and 4x (3/B) 3x and 4x		
C8A (Bullion) ..	4x	Giant	—				Bine 1 (53) Bine 2 (53)	3x and 4x 3x and 4x
C8G (Bullion) ..	4x	Giant	2x and 3x	C8G/A Bine 1 (52)	3x and 4x 3x	(A/B) 3x and 4x 3x and 4x		

TABLE 2
RESULTS OF COLCHICINE TREATMENT OF THE VARIETY
EASTWELL GOLDING

Hill No.	Seedlings, 1953	Cutting No.	Seedlings, 1954	Basal cutting No.	Seedlings, 1954
CEG b 1	3x	CEG b 1/A b 1/B b 1/C	2x 2x 3x and 4x	b 1 Bine 1 (53) b 1 Bine 2 (53)	2x and 3x 2x
CEG b 2	3x	b 2/A b 2/B	3x 3x	b 2 Bine 1 (53) b 2 Bine 2 (53)	2x 2x

In the case of CEG b2, all five seedlings examined from the 1952 seed collection were triploid. Both the cuttings taken in the same year have since given seedlings which were all triploid, yet two bine-seed collections from CEG b2 in 1953, gave only diploid seedlings.

A similar situation is found with the other plant, CEG b1, though here it is not so remarkable, since there is evidence from the cuttings taken in 1952 that the plant was largely composed of diploid tissue even then. A triploid seedling found in the 1953 bine-seed collections suggests that all the tetraploid tissue has not disappeared from this plant.

It would appear that in the case of Eastwell Golding, colchicine treatment resulted in the production of a high proportion of tetraploid tissue, but that subsequently this has been practically swamped by more rapidly growing diploid cells—the situation anticipated by Dark.

The number of plants of each variety that could be examined was small, and the results cannot be taken as indicating that the different behaviour in the two cases was necessarily a varietal characteristic. It may be the result of other factors, such as the difference in early treatment, when one set of laterals was layered and the other not.

From the practical point of view the results emphasize how important it is that efforts to isolate wholly tetraploid material by layering and taking cuttings should be started as soon as possible after colchicine treatment.

(2) MODIFICATIONS TO COLCHICINE TREATMENT METHODS

Whereas the colchicine treatment of Brewer's Gold and Bullion in 1950 was very successful, the treatment of Fuggle and WFC81

(Wye Field Golding) in the same year, of Petham Golding, Eastwell Golding and Early Bird in 1951, and of OB53 (Nonsuch) in 1952 met with very limited success.

It was decided in 1954 to try the effect of increasing the concentration of colchicine, and extending the period of application. In addition, the effect of leaving only one bud for treatment was compared with the earlier method of treating eight buds on each shoot.

The treatments used were:

- (a) 0.5 per cent. colchicine painted on buds three times a day for three days
 (b) 0.5 " " " " " " " " " " four "
 (c) 0.75 " " " " " " " " " " three "
 (d) 0.75 " " " " " " " " " " four "

The main treatment was on Fuggle with three replicates. Two replicates were on single buds, in the third replicate eight buds were treated on each shoot.

In addition, two English male hops ♂169 and ♂A1 were treated, with a single replicate, using eight buds per shoot for each variety.

The results are summarized in Table 3 where N indicates that only normal stomata were found on the lateral, which was, therefore, discarded. (2x) indicates the occurrence of struck laterals in which only diploid cells were found in the root tips, (4x) only tetraploid cells, and (2x+4x) a mixture of diploid and tetraploid cells in the roots of the same lateral.

TABLE 3
RESULTS OF FOUR DIFFERENT COLCHICINE TREATMENTS

	0.5 per cent. 3 days	0.5 per cent. 4 days	0.75 per cent. 3 days	0.75 per cent. 4 days
Fuggle 8 buds	N	(2x)	(2x) (2x+4x)	(2x) (2x+4x)
" 1 bud	(2x) (2x+4x)	(2x)	Lateral died	No laterals
" 1 bud	N	No laterals	(4x) (2x+4x)	Lateral died
♂169 8 buds	No laterals	(2x)	(4x) (2x+4x)	(4x) (2x+4x)
♂A1 8 buds	N	(2x)	N	(2x) (2x+4x)

In cases where no laterals were produced or laterals died after being detached from the parent plant, this did not appear to be associated with the colchicine treatment.

In spite of the limited number of shoots which could be treated, there is apparent a very marked improvement resulting from the

use of the higher concentration of colchicine, but there is not sufficient difference between the three and four-day treatments to justify any conclusions being drawn. Nor does there appear to be any advantage in only leaving one bud per shoot for treatment.

B. SEEDLINGS RAISED FROM COLCHICINE TREATED MATERIAL

(1) PLOIDY

In general the ploidy of seedlings raised from colchicine treated material has been in accord with the assumption that only haploid pollen grains were available for pollination. Thus diploid and triploid seedlings were to be expected, while the occurrence of two pentaploids in the progeny of C4A presumably indicates that some octaploid tissue was produced as a result of the colchicine treatment.

A few aneuploids have been discovered. The first, raised in 1952, was a seedling from chimaerical material of Bullion, and had 21 chromosomes. Though still alive at the end of 1954, it has always been weak and stunted, and has failed to flower.

The second aneuploid, raised in 1953 from tetraploid Bullion, had 32 chromosomes. It is a very vigorous female plant. Two more seedlings with 32 chromosomes and one with 31, were raised in 1954, but it is as yet too early to judge their growth.

A most unexpected result of root tipping seedlings from colchicine treated material, has been the discovery of a number of tetraploid seedlings.

In 1953, open pollinated seed from colchicine treated material was sown in miniature soil blocks or in seed boxes. Chromosome counts were made on 180 seedlings, of which 51 proved to be diploid, 128 triploid and 1 tetraploid. The tetraploid was a seedling of C8G/A, the other seven seedlings from this plant being triploids.

In the winter of 1953-54 open pollinated seed from the 1953 collections was germinated in petri dishes in an incubator, for chromosome counts on the seedlings. The distribution of the 202 seedlings counted was 64 diploids, 133 triploids, 3 tetraploids and 3 pentaploids. Attempts to pot up the more interesting seedlings and grow them on were unsuccessful. All three tetraploid seedlings came from bine collections which otherwise yielded only triploid progeny.

In 1954 more seed was sown in miniature soil blocks. Some of this seed was the result of controlled crosses, the remainder was open pollinated. The distribution of the resulting 190 seedlings is shown in Table 4.

TABLE 4

		2x	3x	4x
Controlled crosses	..	—	71	9
Open pollinated	..	57	53	—

The striking fact about these results is that all the tetraploids occurred in controlled crosses.

In Table 5 the occurrence of tetraploids amongst all triploid families for the years 1952 and 1953 is summarized.

TABLE 5

		3x	4x	Percentage 4x
1952 seed	Open pollinated ..	128	1	0.78
1953	„ „ „ „ ..	186	3	1.61
1953	„ Controlled crosses ..	71	9	12.67

The more frequent occurrence of tetraploids from controlled crossing than from open pollination is very marked. The tetraploids have all occurred in progeny that were otherwise triploid: it therefore seems certain that they have arisen from tetraploid female tissue. The male parents used in the crosses are diploid, and no tetraploid males are known to exist in the gardens.

There appear to be two ways in which these tetraploids could arise. Firstly by parthenogenesis (i.e. by development from the egg mother-cell without meiosis occurring, and without fertilization). Parthenogenesis might be encouraged by artificial pollination, because pollen is then withheld for some time, moreover, the pollen used may be weakened by storage. If parthenogenesis were the cause of these tetraploids they should closely resemble the female parent. But the tetraploid raised in 1953 is male with a few female flowers, while the nine raised in 1954, though not flowering yet, appear to be segregating with regard to such characters as leaf shape.

The second method by which tetraploids could arise would be by pollination by unreduced pollen grains from a diploid male. If the ratio of unreduced to normal pollen is low, the chances of normal pollen reaching a stigma first are correspondingly high. When controlled pollination is carried out, a mass of pollen is deposited at the same moment. The chances of unreduced pollen

effecting fertilization would not be increased by this means unless the pollen tube of the unreduced pollen had a higher rate of growth than the tubes of haploid pollen.

The results of the past two years require confirmation and elaboration before the origin of these tetraploids can be established.

(2) SEX RATIOS

Triploid seedlings of Brewer's Gold and Bullion have included a high proportion of intersexes, but a similar state of affairs is found in many diploid families. Moreover, both these female parent varieties sometimes produce male flowers, so there is no real evidence that the monoecious habit of the seedlings is associated with their triploid nature.

Seedlings have been classified as entirely male or female, predominantly male or female, or a mixture. The degree of monoecism varies with the season, and it seems justifiable to include pure female (or male) in the same class as predominantly female (or male). So far 86 open pollinated seedlings of tetraploid Bullion and 13 of tetraploid Brewer's Gold have been classified as shown in Table 6.

TABLE 6

	Female	Mostly Female	Mix- ture	Mostly Male	Male	Percentage Male
Bullion	34	16	2	12	22	
	50		2	34		39.5
Brewer's Gold ..	6	1	1	4	1	
	7		1	5		38.5

The figures quoted in Table 6 indicate a higher proportion of males than would be expected from a normal diploid family, but the numbers involved are too small to be conclusive.

Some 190 seedlings from tetraploid Bullion by controlled crosses should be available for classification in 1955, while it is hoped to raise in the same year a diploid and a triploid family for direct comparison.

In order to investigate further the relationship between polyploidy and sex ratio, work has been started on the production of tetraploid male hops.

(3) COMMERCIAL PROMISE

Dark has pointed out that triploid hops might have three valuable properties. First, under conditions of normal pollination, they should produce fully grown out cones containing little or no seed. Secondly, triploid hop plants might show an increase in vigour when compared with the diploid female parent. Thirdly, a family of triploid seedlings should show more similarity to each other and their female parent, than is the case with a normal diploid family.

The first triploid seedlings were planted out in 1952, and since then, observations have been made in the field, and samples of hops have been picked and analysed.

The results to date—with respect to these three properties—are here considered in order of importance, bearing in mind the different requirements of brewers and growers. Whereas brewers are satisfied with the established varieties, growers are seeking new varieties combining disease resistance, suitability for machine picking, etc., with higher yields.

(a) *Resemblance to parent variety*

The only triploid plants which have so far been available in any number, for comparison with the parent variety, have been open pollinated seedlings from tetraploid Bullion.

The female seedlings have shown a high degree of uniformity, and resemblance to their female parent, not only in their appearance in the field, but also in the aroma and preservative value (P.V.) of their dried hops.

To date, dried hop samples of 29 triploids from Bullion have been submitted to Colonel Richardson of Messrs. Wigan, Richardson, for an opinion on their aroma and possible commercial value. Of these, 8 were described as having a pleasant mild American aroma, 16 had a harsher American aroma, but were said to be acceptable as hops of the Bullion class; only 5 were considered to be markedly inferior to Bullion, and to be unacceptable.

Samples from the 1952, 1953 and 1954 triploid crops submitted for resin analysis have shown that of 37 varieties, 16 had P.Vs. of the same order as Bullion, 16 were appreciably higher, and 5 were lower.

Comparative small-scale brewing trials were carried out by the Brewing Industry Research Foundation, with 10 triploid seedlings of Bullion, and Bullion itself, from the 1953 crop. Results indicated that 8 of the seedlings were as good as, and in most cases preferable to, Bullion.

(b) Sterility

Triploid hops have proved to contain much less seed than diploids. A sample of 10 gm. of dried hops from a triploid in 1954, yielded 2.8 per cent. seed by weight. In a diploid variety, 13-14 per cent. would be expected. Out of 184 seeds separated from the triploid sample, only 20 had any sort of embryo.

A further nine samples, each of 50 ripe cones, yielded an average of 16.2 seeds per 50 cones. Similar samples were taken from four commercial varieties at the same time and these yielded an average of 282 seeds per 50 cones.

(c) Vigour

Well-established triploid seedlings of Bullion and Brewer's Gold have proved to be more vigorous than their diploid parents—themselves strong growing varieties. This increase in vigour caused severe tangling of the heads on normal wirework.

Large cones, rather singly distributed on the bines, were produced by most hills in 1952 and 1953: in 1954 the same plants yielded bigger crops of much smaller cones. In a diploid variety, this increase in number and reduction in the size of the cones, is expected as the hill ages.

(d) Conclusions

It has been shown in the case of Bullion, that triploid female seedlings raised from a tetraploid form of this variety, resemble it closely. It remains to be seen, whether the same result will be obtained when triploid families from other varieties are raised.

Assuming more or less the same result from any cross involving a commercial variety, the apparent advantages need closer examination.

The resemblance of triploid seedlings to the tetraploid maternal parent may greatly assist the work of breeding new varieties, since it becomes easier to reproduce the known commercial properties of the female in the offspring. It must, however, be realized that it may well be correspondingly difficult to introduce desirable characters, such as disease resistance, from the male parent, since its contribution to the genetic make up of the offspring is only half that of the tetraploid female.

Although almost seedless, triploid hops do grow out as a result of pollination, in the manner described by Salmon and Amos (1908), so that larger cones and heavier yields can be expected

than when the seedless condition is obtained by eliminating the male hop in a diploid garden.

Rabak (1943) has shown that seedless diploid hops obtained by the elimination of males, contain a higher proportion of α resin than do seeded hops (calculated on a seed-free basis). A similar real increase in P.V. may be occurring in the triploids, but most of the increase is undoubtedly due to their lower density, resulting from the lack of seed.

Another aspect of this lower density in triploids, is that pockets of these hops may be expected to weigh appreciably less than pockets of diploids. There will thus be an apparent loss of yield due to the absence of commercially useless seed. It appears that it may be necessary to consider a higher valuation to compensate for this loss of weight, so that the value of a pocket remains the same.

The increased vigour displayed by the triploid seedlings of strong growing varieties may prove to be a handicap, unless higher wirework and wider spacing is used to avoid the crop being "housed in". On the other hand, when triploids are bred from less vigorous varieties, their stronger growth may prove an advantage even on normal wirework.

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THE TESTING AND SELECTION OF FUGGLE AND GOLDING CLONES

PROGRESS REPORT I

F. H. BEARD and F. C. THOMPSON

Trials are being made at Wye of different clonal stocks of Golding and Fuggle hops with the object of selecting those showing the best cropping performance allied to high preservative value and other desirable qualities. Attention is also being paid to selecting early, midseason and late clones of both Golding and Fuggle varieties to meet the demands of machine picking.

The origins of the present Wye selections of both Golding and Fuggle clones are diverse, and it was thought desirable to summarize the position to date and show the lines on which it is proposed to test and develop these clones in the future.

FUGGLE CLONES

Originally about a dozen strains of Fuggle were planted at East Malling Research Station to be used as "controls" for comparison with the New (Wye) Varieties of hops which were then being tested there. These Fuggle strains had been collected by Professor E. S. Salmon from good commercial growers, but were not clonal stocks. From these strains, however, Beard (1942) established three clones which were planted out in a trial in 1931; one of these clones, the now well-known Fuggle "N", was found to be distinctly superior to the others and is widely grown commercially at the present time.

As a result of this work by Beard it was considered desirable in 1943, to test a wider range of material, and since certain strains of "early" Fuggles had come into some prominence commercially, it was decided to include these in the trial. As the original series of Fuggle strains at East Malling, from which Fuggle "N" clone had been selected, had been grubbed in order to make room for testing the New (Wye) Varieties, it was necessary to make a fresh collection of basic material. One source was the "museum" established at Wye by Professor Salmon, which included Fuggle stocks from a number of sources, including material from several European

countries, from the U.S.A., and from a very old-established stock in Worcestershire. In addition, in 1943, Beard and Dr. A. H. Burgess made a tour of commercial gardens producing "early" and "large-coned" Fuggles in the Kentish Weald, and marked selected hills from which strap cuts were later taken. From these sources 28 clones were raised by Beard and planted out for observation in two-hill "plots" at East Malling.

A further source of material originated from a collection at East Malling of 50 different Fuggle stocks assembled by Dr. W. G. Keyworth from the various hop growing districts in England, as part of a survey designed to ascertain to what extent commercial Fuggle stocks were actual, as distinct from potential, carriers of mosaic disease. This material was eventually incorporated in the clonal Fuggle collection, and for record purposes is referred to as the "Pathology" collection.

Just as these various clones of Fuggle hops were becoming well established the work was transferred to Wye, with a consequent delay in again establishing mature plants. The few seasons' observations at East Malling had, however, enabled the 78 clones to be reduced to 39 at the time of transfer. Further observations in the field at Wye, coupled with resin analysis of the cones have resulted in the number now being reduced to 10 clones, which are considered sufficiently promising to be worked up for large-scale trials, providing enough material for brewing tests.

Details of the present selection of clones are as follows:

- (1) A Fuggle from Worcestershire with a known history dating back to 1879, showing a good performance and resin analysis.
- (2) A Fuggle from the Weald of Kent which, in addition to good performance and resin analysis, produces cones of larger than average size.
- (3) - (7) Fuggles from the "Pathology" collection at East Malling. Unfortunately no details are available as to the source of origin of these selections. They have all, however, shown good performance and resin analysis.
- (8) - (10) Three strains of early Fuggles. While these have proved to be the best of all the early Fuggle strains tested, results to date show that their resin analysis figures are lower than those found for the midseason selections.

It should, perhaps, be pointed out that apart from these three early strains all the other Fuggle strains under observation have

shown themselves to be midseason with no appreciable difference in time of ripening. There has been no indication of the existence of a "late" Fuggle.

Disease resistance

Among the factors taken into account in assessing performance in the field, disease resistance is of great importance. The Fuggle variety is not sensitive to mosaic disease, being a carrier of the virus, and the variety also shows a measure of resistance to the downy mildew fungus. Fuggles, however, are sensitive to the virus diseases of nettlehead and split leaf blotch. The ten selected clones described above have all shown freedom from these latter two virus diseases. In addition, they have been little affected by downy mildew.

GOLDING CLONES

The testing and selection of Golding clones is a much bigger task than the Fuggle project owing to the large number of types of Golding in existence. At least seven named Goldings are known to be cultivated, i.e. Early Bird, Canterbury, Eastwell, Rodmersham, Petham, Bramling and Mathon, but this large number of types is grown on a very limited proportion of the total hop acreage. Individual growers have strong preferences for specific types and are unwilling to change, although apart from "season" there is little, if any, apparent difference between them. This means that at the present time, any propagator willing to take up the production of Golding stocks may have to carry small stocks of a wide range of types, which few are prepared to do. The aim at Wye is to produce three selected clones of early, midseason and late Goldings from a large collection of material built up at East Malling and Wye over a period of years.

As long ago as 1937 attention was being paid to the selection of tested clonal strains at East Malling, but the work was greatly hampered by the incidence of mosaic disease. This was particularly so in the early years when the significance of "carrier" varieties was not understood, and the fact that such varieties, though making satisfactory growth themselves, could infect neighbouring "susceptible" varieties, was not fully appreciated. It was not, therefore, until 1943 that it was possible to lay down at East Malling a trial with a series of seven Goldings, comprising two early season strains and five of later ripening period. A report on this trial has recently appeared (Beard, 1952).

In 1937 the problem was tackled on a more ambitious scale by Dr. Burgess at Wye. Through the aid of the hop factors, growers of the best quality Goldings were traced and Dr. Burgess then visited selected gardens belonging to five growers during the growing season, marking a number of typical healthy hills in each garden. From these marked hills a single strap cut was later taken and planted in Wye Field. Owing to the incidence of mosaic disease this trial was later grubbed and a fresh collection of material from the same marked hills was made in 1939 and planted in Wood Field in isolation from other hops at Wye.

Four growers in East Kent and one in mid-Kent were thus picked out to provide material of five Goldings; Bramling, Early Bird, Eastwell, Rodmersham, Canterbury. These growers are later referred to as A, B, L, P and T respectively. No grower was able to supply material of all varieties and the sources of supply were therefore as follows: Bramling 3, Early Bird 3, Eastwell 4, Rodmersham 1, Canterbury 2. In addition, three growers were able to supply cuts of the "Golding Variety" Cobbs.

The outbreak of war checked any further development at Wye until 1949 when cuts from the clones in Wood Field were planted up in four-hill observation plots in the recently-acquired Silks Garden at Wye which was well removed from other hop gardens and intended for mosaic-sensitive varieties. Similar plots of the already tested East Malling Golding clones were planted in Silks Garden at the same time. The bulk of the garden was filled up with large plantings of East Malling clonal Early Bird, Petham and Eastwell Goldings; these plantings will eventually make way for randomized trials of selections from the newer clones. A total of 113 clones was planted in Silks Garden as shown below:

Variety	Source of material						Total
	1(A)	2(B)	3(L)	4(P)	5(T)	E.M.R.S.	
Early Bird ..	4	7	9	—	—	1	21
Bramling ..	—	—	7	6	7	1	21
Eastwell ..	5	6	2	—	4	1	18
Canterbury ..	—	8	5	—	—	1	14
Rodmersham ..	—	8	—	—	—	1	9
Petham ..	—	—	—	—	—	1	1
Mathon ..	—	—	—	—	—	1	1
Cobbs ..	10	9	—	—	9	—	28
	19	38	23	6	20	7	113

Later five clones of Mathon from a Worcestershire source were added, making a total of 118 clones.

The choice of a limited number of clones for further testing has not been easy, as apart from two Bramling clones that were obviously misnamed, all the clones have been, so far as can be judged from a very few hills, of satisfactory vigour and health. Observations on the Golding clones at East Malling had shown some variation in the production of downy mildew spikes and in rootstock infection by the fungus, between the different types of Golding, but no study had been made of any possible variations in susceptibility to the disease between different clones of the same Golding type. This factor will be investigated at Wye when sufficient planting material has been built up for the establishment of large trial plots, four-hill plots being too small to allow reliable observations to be made on susceptibility to downy mildew. Owing to the large amount of land taken up with large-scale plots, some selection of the large number of clones established in four-hill plots had to be made, using vigour of growth and resins content (preservative value) as criteria. Analyses were made on the Wood Field parent hills from 1946 to 1951, but unfortunately not all hills were analysed in each year. Nevertheless, it has been possible to select clones which show better mean preservative values than others.

From the original total of 118 clones, twenty Goldings and four Cobbs have been selected as follows, and are now being propagated for more extensive tests:

Variety	Clones	Season
Early Bird	Four clones: A4, A6, A10, E.M.R.S.	Early
Bramling	Four clones: P4, P6, T8, T9	Early
Petham	One clone: E.M.R.S.	Midseason
Rodmersham	Two clones: B1, E.M.R.S.	Midseason
Mathon	Two clones: M3/91, E.M.R.S.	Midseason
Cobbs	Four clones: A9, B3, B8, T10	Midseason
Eastwell	Four clones: A3, B2, L3, E.M.R.S.	Midseason-Late
Canterbury	Three clones: B3, B9, E.M.R.S.	Late

It is intended to plant a total of at least 40 hills of each clone in replicated trials. This should be sufficient to give reliable data on yield and brewing qualities, and also on resistance to diseases, especially downy mildew.

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OBSERVATION TRIALS WITH THE NEW VARIETIES OF HOPS

PROGRESS REPORT I

F. H. BEARD and F. C. THOMPSON

While records are available of the growth and cropping of the New (Wye) Varieties of hops on the soils at Wye and East Malling, precise information on their performance on other soils and in other districts has hitherto been lacking. In 1952, however, through the courtesy of Captain A. O. R. Beale, an observation trial was laid down in a hop garden at Castle Farm, Sissinghurst, in the High Weald of Kent.

The varieties planted, in eighty-hill plots, were:

Pride of Kent
John Ford
Malling Midseason
Northern Brewer
College Cluster
Early Choice

Not enough bedded sets were available to plant up all the plots, certain of which had to be completed with cut sets. Establishment differed with each variety, but in all plots some blanks occurred in the first year and it was not until 1954 that any of the varieties were considered to be sufficiently well established for crop records to be taken. Brief notes on the observations made in 1952 and 1953 are given below:

Pride of Kent. 1952 (July 22nd): Hills from bedded sets making only fair growth, hills from cut sets very weak.

1953 (June 11th): Plants generally weak. Some downy mildew showing up, but not severe.

John Ford. 1952. Hills from bedded sets, showing generally good growth; hills from cut sets rather weak.

1953. Most striking feature was severe incidence of downy mildew—many terminal and lateral spikes showing and some fungus

infection of lower leaves. The disease was brought under control later in the season.

Malling Midseason. 1952. Hills from bedded sets showing good growth; hills from cut sets much weaker, with a few very weak plants.

1953. Growth rather weak and uneven; only slight incidence of downy mildew.

Northern Brewer. 1952. Growth uneven with a large number of blank hills.

1953. Fair growth; only slight incidence of downy mildew.

College Cluster. 1952. Very good take, with useful, strong growth.

1953. Fair growth, largely free from downy mildew.

Early Choice. 1952. Good growth.

1953. Good growth and colour; largely free from downy mildew.

The position was assessed at the end of the 1953 growing season when it was decided by Mr. Stern, who is responsible for running the plots at Sissinghurst, that the variety John Ford was too susceptible to downy mildew for his conditions, and in addition, the variety Malling Midseason was showing a high percentage of dead hills owing to downy mildew infection of the rootstocks. In consequence, after consultation with Wye, it was decided to grub these plots and plant with the varieties Norton Court Golding and Bullion, respectively.

OBSERVATIONS MADE IN 1954

In this year records were taken on June 18th, when it was noted that Early Choice, College Cluster and Northern Brewer, were all making useful growth, though in each variety there were some blank hills. Pride of Kent, however, was only fair with many weak hills. There was evidence that aphid attack had been severe, but had been brought under control by this date. A number of downy mildew spikes were noted in all varieties. As mentioned above, the plots of Norton Court Golding and Bullion were only planted in this year.

The plots were next seen on August 10th, when it was again noted that growth of Pride of Kent was weak. Northern Brewer was showing fairly good growth, but many "heads" had been damaged by earlier gales. College Cluster and Early Choice were

both looking well, with good growth. College Cluster was actually further in hop than Early Choice, with both ahead of Northern Brewer. There were no obvious signs of downy mildew infection or aphid infestation on any of the plots, though both had been severe earlier in the season.

Mr. Stern was able to take crop yields from three of the plots, the yields in terms of cwt. per acre dry hops being:

Northern Brewer	..	20·7
College Cluster	..	26·0
Early Choice ..	..	19·4

In 1954 a second observation trial was planted in a fold of land on the lower slopes of the North Downs at Maplescombe, near Farningham, Kent, through the courtesy of Mr. E. E. Taylor. The varieties planted were:

Early Choice
College Cluster
Northern Brewer
Norton Court Golding
Sunshine
Pride of Kent

This trial is just in the establishment phase. The take in general has been fair to good, with the exception of the variety Sunshine; in this latter plot growth was very weak in 1954 and there were many blank hills.

It should be pointed out that, at both sites, the hops are planted on soils of good depth and texture, representing the better soils of these areas.

HEIGHT OF WIREWORK AND SPACING TRIAL

PROGRESS REPORT II

F. H. BEARD and F. C. THOMPSON

A report on the results obtained from this trial in 1953 appeared in the previous Annual Report (Beard and Thompson, 1954), when a brief account was given of the layout of the experiment, the object of which is to ascertain the combination of height and spacing which will produce the type of growth considered most suitable for machine picking, while at the same time giving satisfactory crop yield.

There are three heights of wirework, 13 ft., 15 ft., and 17 ft. 3 in., combined with three spacings in one direction of 6 ft., 7 ft. 6 in., and 9 ft. The cross spacing is uniform at 6 ft. 6 in. to facilitate cross cultivation. This means that, considered as a square plant, the spacings are approximately 6 ft., 7 ft., and $7\frac{1}{2}$ ft. square, respectively. There are two replications of each combination of height and spacing, and the treatments continue across four varieties of hops; of these the varieties Fuggle and John Ford were planted as layer cuttings in 1951, while the varieties Bullion and Brewer's Gold were planted as bedded-sets at the same time.

1954 RESULTS

(a) *Pattern of growth*

Observations were carried out during the growing season and detailed records of growth were taken at the end of August, 1954.

With the Fuggle variety, with the narrowest spacing, there was a tendency for the lower laterals to be barren at all heights and heads were formed except with the highest wirework; with the medium spacing there were similar trends, but with the widest spacing, at all heights, there was an absence of heads and the crop developed well down the bine.

With John Ford, differences in growth with the different heights and spacings were not so marked as with the other varieties; even at the narrowest spacing and lowest height no heads were

formed and the crop developed well down the bine; the best performance was assessed to be at $9 \times 6\frac{1}{2}$ ft. spacing and 15 ft. height.

With the strong growing variety Bullion, the hops were badly housed-in, with big heads, at the 13 ft. height at all spacings, while at 15 ft. height similar growth was observed except at the 9 ft. spacing; at $17\frac{1}{4}$ ft. the hops were housed-in at the narrower spacings, but showed good growth at the 9 ft. spacing.

With the other strong growing variety, Brewer's Gold, growth at the different heights and spacings was similar to that found with Bullion, except that there was not the marked difference between the 9 ft. and $7\frac{1}{2}$ ft. spacings at the $17\frac{1}{4}$ ft. height.

(b) Yields

The plots were harvested in September, 1954, and Table 1 is a summary table giving the yields per hill in terms of bushels. As pointed out in the previous report, while these figures are of interest in showing the marked increase in yield per hill with the wider spacing, it should be emphasized that this does not result in an increased yield per acre. Data for the latter are shown in Table 2, which gives the yield in cwt. per acre for all combinations of treatments tested.

TABLE 1
YIELD DATA IN BUSHELS PER HILL*

Variety	Height			Spacing		
	$17\frac{1}{4}$ ft.	15 ft.	13 ft.	9 ft.	$7\frac{1}{2}$ ft.	6 ft.
Fuggle	3.03	3.07	2.93	3.37	3.05	2.61
John Ford .. .	2.62	2.44	2.36	2.73	2.51	2.19
Bullion	2.79	2.49	2.56	2.97	2.57	2.30
Brewer's Gold ..	2.77	2.44	2.54	2.94	2.62	2.20

* Estimated on the basis of 5 lb. green hops = 1 bushel.

In arriving at the yield in cwt./acre of dry hops, shown in Table 2, the yield of green hops as weighed has been converted to dry weights, calculated from the percentage of dry matter found in each variety by a sampling technique. The per cent. dry matter was found to be: Fuggle 18.1; John Ford 20.2; Bullion 24.7; Brewer's Gold 24.9.

The yield data given in Table 2 cannot thus be compared directly with the yields of dry hops obtained in 1953, since the latter were estimated from the green weights on the basis of 4 lb.

TABLE 2

WEIGHT OF HOPS PICKED IN 1954 IN CWT./ACRE DRY HOPS

Variety	Spacing	Hills per acre	Heights			Mean Yield (Different spacings)
			17½ ft.	15 ft.	13 ft.	
Fuggle "N"	9 × 6½ ft.	745	19.31	21.18	20.03	20.17
	7½ × 6½ ft.	893	22.64	21.89	21.04	21.85
	6 × 6½ ft.	1,117	24.21	23.45	22.53	23.39
Mean Yield (heights)			22.05	22.17	21.20	21.80
John Ford	9 × 6½ ft.	745	18.74	18.28	17.18	18.07
	7½ × 6½ ft.	893	21.21	19.46	18.58	19.75
	6 × 6½ ft.	1,117	23.62	21.30	20.70	21.87
Mean Yield (heights)			21.29	19.68	18.82	19.90
Bullion	9 × 6½ ft.	745	24.80	23.56	24.86	24.41
	7½ × 6½ ft.	893	27.26	24.16	24.32	25.25
	6 × 6½ ft.	1,117	31.47	26.26	27.20	28.40
Mean Yield (heights)			27.84	24.66	25.46	26.02
Brewer's Gold	9 × 6½ ft.	745	25.16	22.98	24.67	24.27
	7½ × 6½ ft.	893	27.76	25.15	25.38	26.10
	6 × 6½ ft.	1,117	30.48	25.52	26.10	27.40
Mean Yield (heights)			27.80	24.55	25.38	25.92

Statistical Analysis

Fuggle: Highly significant effects due to spacing.

John Ford: No significant effects.

Bullion: No significant effects.

Brewer's Gold: Significant effect due to spacing.

green hops = 1 lb. dry hops. On green weights, however, the 1954 yield of the variety Fuggle showed an appreciable increase over that of 1953, while the other three varieties showed in general a fall in yield. Seasonal conditions in 1954 did not favour a heavy yield of hops and, in addition, the incidence of downy mildew was very severe. In this experiment, the susceptible varieties John Ford, Bullion and Brewer's Gold were all affected to some degree with downy mildew on the cones, whereas Fuggle was relatively free from the disease, and this factor undoubtedly favoured the Fuggle crop. The variability in plot yield resulting from downy mildew

infection may account for the lack of significance between treatments found with the varieties John Ford and Bullion.

Detailed comments on the yield data obtained are given below:

Fuggle

Yield per hill: There is a marked increase in yield with increase in spacing, at all heights; the effect of spacing is highly significant. The influence of height on yield is not marked and not significant. The highest yield is found at 9 ft. spacing and 15 ft. height.

Yield per acre: In contrast to the figures for yield per hill, there is a highly significant *decrease* in yield with increase in width of spacing. With increase in height there is an increase in yield which approaches significance. The highest yield is found with 6 ft. spacing and $17\frac{1}{4}$ ft. wirework.

John Ford

Yield per hill: There are no statistically significant effects showing, but the major effect is the increase in yield with increase in width of spacing. The highest yield occurs with 9 ft. spacing and $17\frac{1}{4}$ ft. wirework.

Yield per acre: Here again there are no significant effects, but the major effect is that due to spacing, the yield decreasing as the width is increased. There is also an appreciable increase in yield with increase in height. The 6 ft. spacing and $17\frac{1}{4}$ ft. wirework gives the highest yield.

Bullion

Yield per hill: With this variety there is a significant increase in yield with the wider spacings and an appreciable, though non-significant, increase with the higher wirework. Highest yield with 9 ft. spacing and $17\frac{1}{4}$ wirework.

Yield per acre: There are no significant effects, but an appreciable increase in yield occurs with the higher wirework and a decrease in yield with the wider spacings. The highest yield is found with 6 ft. spacing and $17\frac{1}{4}$ ft. wirework.

Brewer's Gold

Yield per hill: There is a statistically significant increase with the wider spacings, and an increase with the higher wirework, the latter not significant. The 9 ft. spacing and $17\frac{1}{4}$ ft. wirework gives the highest yield.

Yield per acre: There is a significant decrease in yield with the wider spacings; increase in height of wirework increases yield, but the effect is not significant. The highest yield is found with 6 ft. spacing and $17\frac{1}{4}$ ft. wirework.

(c) *Effect on resin content*

Samples of hop cones were taken from each plot in 1954 and analysed by the method of Ford and Tait. In all the varieties except Brewer's Gold the Total Soft Resins increased consistently with increase in height of wirework and to a lesser extent with increase in width of spacing. In the case of Bullion the increase in Total Soft Resins with increase in height was statistically significant. In the Fuggle and John Ford the increases were not significant, but in the John Ford this lack of significance was probably due to plant to plant variations caused by gapping up where hills had died through downy mildew disease. The variety Brewer's Gold showed no appreciable variation in resin content with the different heights and spacings.

These increases in Total Soft Resins were due mainly to the effect of height and spacing on the non-alpha resin fraction. In contrast, the alpha resin content showed no consistent trends except in John Ford, where it rose with increase in height and to a lesser extent with increase in width of spacing. Neither of these differences, however, was statistically significant.

DISCUSSION AND CONCLUSIONS

The data given in Table 1 show similar trends to those found in 1953, the main difference being that the variety Fuggle has produced appreciably more bushels per hill in 1954, while the variety Bullion has produced appreciably less, the other two varieties showing little change.

When the data in Table 2 are considered it will be seen that as in 1953, the influence of width of spacing on yield is again a dominant feature and the effect of the larger number of hills per acre on the narrowest spacing, outweighs the effect of increased yield per hill found with the wider spacings. It was thought that as the plant became more fully established, the wider spacings would encourage the development of a larger root system which in turn would have an increased effect on the yield per hill, but this has not materialized. It is, in fact, noteworthy that the variety Bullion, which in 1953 showed an increased yield of 1.4 bushels per hill where the spacing

was increased from 6 ft. to 9 ft., in 1954 showed an increase of only 0.7 bushels per hill under the same treatments.

It is of interest to note that Keller (1953) has recently reported the results of experiments carried out at the Oregon Experiment Station in the U.S.A., in which the effect of varying the width of spacing was studied. The results showed a marked increase in yield per acre with the narrower spacings, the increase being of the order of 50 per cent. as the planting width was reduced from 8 ft. $\times$ 8 ft. to 4 ft. $\times$ 4 ft.

The influence of the height of wirework has been more pronounced and more consistent in 1954 than in 1953, the general effect being for yield to increase as the wirework is raised. The 1954 results, thus lend further support to the conclusion drawn from the 1953 results that increasing the height of wirework produces the type of growth considered suitable for machine picking without having the unfavourable effect on crop yield shown by increasing the width of spacing.

The effect on resin content was studied for the first time in 1954, and the results suggest that increase in height and to a lesser extent in width of spacing may raise the production of Total Soft Resins mainly by increasing the non-alpha fraction. This increase may possibly be due to the increased amount of light reaching the plants through the more open growth associated with higher wirework and wider spacing. It must be emphasized, however, that the results relate to a single season only, and they should be accepted with caution until confirmed by future work.

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A NOTE ON THE EFFECT OF PREMATURE CUTTING OF HOP BINES ON THE YIELD OF HOPS

F. C. THOMPSON

At the beginning of the century when hops were still commonly grown on poles, necessitating the cutting of the bines at picking time, the late Sir Daniel Hall (1901) at Wye studied the effect of this practice and concluded that it weakened the plant and adversely affected crop yield, as compared with leaving the bines to ripen off before cutting.

At the present time the majority of hops are grown on some system of wirework and, with hand picking, the bines can be left to ripen off before cutting in the late autumn. The difficulty of obtaining hand pickers, however, is now resulting in the widespread introduction of machine picking, and this generally entails cutting the bines for transport to the machine, and once again raises the question as to what harmful effects may arise from this practice. This problem has now been investigated at Wye for some years, and, while it is not proposed, in this note, to give a detailed account of all the results obtained, it was thought desirable to give a brief report of our findings in relation to growers' own observations and in the light of some recent research in Germany.

In 1946, Dr. Burgess laid down an experiment on a piece of hops which was available at the time in Wye Field hop garden and comprised the varieties Early Bird, Cobbs and Canterbury Goldings. Unfortunately the plant was an old one, due for grubbing in the winter of 1949, and contained many weak hills and replants caused by attacks of mosaic disease. Owing to this unevenness of plant the results obtained showed marked variations from plot to plot, and this tended to mask any effects of the applied treatments. In general, however, it could be said that over the three-year period of the experiment, 1947-49, the trend was for a decrease in yield to be associated with cutting the bine.

A similar experiment was laid down in 1950 in a new garden planted in 1949 with the varieties Early Bird, Petham Golding

and Eastwell Golding. Records of crop yield have been taken by Mr. F. H. Beard in each of the five years 1950-54 inclusive, and in no year has there been any significant difference in yield between the plots cut at picking time and those on which the bines are allowed to ripen off. A summary of the data obtained is given in Table 1, from which it can be seen that of the small differences in yield obtained, 50 per cent. are actually in favour of cutting the bine at picking time. The trial, in fact, is a good illustration of how a carefully controlled experiment carried out over a number of years, can yield results which completely contradict pre-conceived ideas, and may serve as a warning to growers to be cautious in jumping to conclusions from casual observations made without any proper controls for comparison.

It should be pointed out that the soil on which the plots are located is one of high fertility on which the hops make vigorous growth. Under less favourable conditions it is likely that the effects of premature cutting may be much more pronounced and result in a weakening of the plant and consequent drop in yield, since chemical investigations at Wye have shown that significant amounts of plant nutrients pass back into the rootstock during ripening of the bine.

The experience of growers who have been picking hops by machine for a number of years, is conflicting. In some cases a marked reduction in yield has been reported; in others the practice has been carried out for many years without any apparent adverse effect on crop. Two factors of importance which have been noted are, firstly, that a plant which has been weakened by machine picking shows a good recovery if it is hand picked for a year or two and the bines left to ripen off; secondly, the time at which the bine is cut during the picking season can be very critical, and if cutting takes place when the hop cones are fully ripe the weakening effect on the plant appears to be much less marked.

It is of interest to note that the prospect of the introduction of mechanical hop picking has prompted a study of the effect of premature cutting on hop growth in Germany. A recent paper by Zattler (1954) gives the results of experiments carried out in the period 1945-49. While cutting the bine at picking time resulted in a drop in yield, the adverse effect did not increase from year to year. Seasonal conditions affected yield from year to year, but in any one year the effect was proportionately the same with both cut and uncut plants. Increased manuring raised the yield of cut plants, but the effect was slight and could not be justified on economic

TABLE I
 *YIELD OF DRY HOPS IN CWTs. PER ACRE FROM PLOTS CUT AT PICKING TIME
 AND PLOTS WHERE THE BINES ARE LEFT TO RIPEN OFF

Variety	1950		1951		1952		1953		1954	
	Cut	Ripened off	Cut	Ripened off	Cut	Ripened off	Cut	Ripened off	Cut	Ripened off
Early Bird ..	23.3	22.6 †(+ 0.7)	25.3	25.8 (- 0.5)	20.6	21.3 (- 0.7)	23.8	24.6 (- 0.8)	18.9	18.6 (- 0.3)
Petham ..	22.5	21.9 (+ 0.5)	27.5	27.4 (+ 0.1)	26.0	25.2 (+ 0.8)	24.5	24.8 (- 0.3)	23.7	23.7 (nil)
Eastwell ..	22.5	22.6 (- 0.1)	26.8	27.3 (- 0.5)	26.1	25.6 (+ 0.5)	26.0	26.9 (- 0.9)	23.1	21.7 (+ 1.4)

* Calculated from yield of green hops on the basis of 5 lb. green hops = 1 lb. dry hops.

† The figures in brackets show the increase or decrease in yield associated with cutting the bine.

grounds; in one series of experiments where the basic manurial application given was, per acre, 59 lb. N, 46 lb. P_2O_5 , and 84 lb. K_2O , increasing this application by 50 per cent. gave an increase of only 0.25 cwt. per acre dry hops (average of four years). When cutting was carried out every other year, instead of every year, only a very slight improvement in yield resulted. Cutting at 3 metres (9.75 ft.) height had appreciably less effect on yield than cutting at 1 metre ($3\frac{1}{4}$ ft.) height; in this connection it should be noted that hops in Germany are grown on 20 to 25 ft. wirework. Cutting was not found to have any significant effect on resin content.

It should be noted that in these German experiments, we are informed that the bines were cut before the hops were fully ripe; at Wye, the bines are not cut until the hops are considered to be ripe enough for picking.

CONCLUSIONS

Mechanical picking is now a significant factor in hop production in England and the number of machines is likely to increase rapidly in the next few years. With the majority of machines in use it is necessary to cut the hop bines at picking time, instead of allowing them to ripen off before cutting, as is the custom with hand picking. There is no doubt that premature cutting prevents the transfer of an appreciable amount of plant nutrients from the bine back to the rootstock, and this might be expected to have a weakening effect on the plant. The magnitude of this effect has yet to be assessed, however, and the evidence to date on its significance is conflicting. Thus, an experiment at Wye on soil of high fertility, has shown no significant drop in yield as a result of premature cutting, over a five-year period, and there are growers who have been machine picking for many years without observing any adverse effect on yield. On the other hand, there is evidence, that under less favourable growing conditions, crop yield may be appreciably reduced as a result of cutting the bine at picking time, and future experimental work must be directed towards sorting out the factors involved so that measures may be devised to overcome the weakening effect of this practice on the plant. In this connection the German work referred to above, in which it was shown that a 50 per cent. increase in fertilizer application gave an almost negligible increase in yield, is of importance, since it is considered that the adverse effects of premature cutting may be associated with a reduction in the carbohydrate reserves in the rootstock rather than with any marked shortage of mineral nutrients.

Whatever the solution to the problem may be, however, it is reasonable to conclude, in our present state of knowledge, that provided the hops are reasonably ripe the effect of cutting the bine at picking time need not be so serious as is sometimes thought.

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A LONG-TERM MANURIAL TRIAL ON HOPS

PROGRESS REPORT 1954

F. C. THOMPSON

In a review of the literature by the writer (Thompson, 1949) it was shown that while a number of experiments had been carried out on the manurial requirements of the hop plant, such experiments were, in general, on a small scale, and the results often conflicting and inconclusive. There was a need for critical fertilizer experiments, particularly to study the interactions of nutritional factors in the growth of hops and to gain knowledge about the optimum levels of nutrients necessary for maximum growth and yield under different conditions. It was also felt that the influence, if any, of manuring on the resin content of the hop cones should be investigated. Further, one of the conclusions drawn from a survey of hop manuring practices, was that among commercial growers hops generally receive very heavy applications of fertilizer, and though the plant responds to heavy manuring, there was the possibility that excessive and unbalanced manuring might lead to induced deficiency disorders resulting in weakened growth and loss of crop. In addition, no previous studies had been made on the nutrient status of the soil and the mineral composition of the plant, as assessed by chemical analysis, in relation to yield response to different fertilizer treatments.

A difficulty which arises in locating fertilizer experiments in established hop gardens is the fact that the heavy manuring given, over a period of years, can mask the effects of any different fertilizer treatments applied. Through the courtesy of Messrs. Arthur Guinness Son and Co. Ltd., an area of land was selected on one of their hop farms at Bodiam, Sussex. The farm in question had only recently been taken over by Messrs. Guinness and the field chosen was on land which had not previously carried hops, but had been in arable cultivation. At the time of planting it was sown down to a grass mixture, but the sward was very poor, and it was evident that before Messrs. Guinness took over, the farm had been allowed to get into rather a derelict condition. The soil is a very fine sandy loam of the Pembury series, derived from the Tunbridge Wells Sand, a type of soil commonly found in the hop growing areas of the High

Weald in Kent and East Sussex; over the experimental area, however, the soil is unfortunately rather variable in depth, in parts showing under 12 in. of top soil, and the structure is generally poor. The low nutrient status of the soil was a factor governing the choice of the site, and at the commencement of the experiment it showed very low values for available potash, phosphate and magnesium. The plots were planted with cut sets of the Fuggle variety and fertilizer treatments begun in 1949, but 1951 was the first year in which the plant could be regarded as fully established and satisfactory data collected on crop yield and nutrient uptake.

The statistical layout adopted is a factorial design of great flexibility, allowing for the incorporation of new treatments as the experiment proceeds. It was adopted on the advice of Dr. S. C. Pearce of the Statistical Department at East Malling Research Station and was based on their long experience in designing experiments with fruit trees. A plan of the experiment is given below.

PLAN OF MANURIAL TRIAL
Block 2 Block 1

K ₂ P ₂	K ₁ P ₁	K ₂ P ₁	K ₁ P ₂	K ₂ P ₁	K ₁ P ₁	K ₂ P ₂	K ₁ P ₁
N ₂ O	N ₂ Mg	N ₁ O	N ₁ O	N ₂ O	N ₁ Mg	N ₁ Mg	N ₁ O
K ₁ P ₂	K ₂ P ₁	K ₂ P ₂	K ₁ P ₁	K ₁ P ₂	K ₂ P ₂	K ₁ P ₂	K ₂ P ₁
N ₁ Mg	N ₁ Mg	N ₂ Mg	N ₂ O	N ₂ Mg	N ₁ O	N ₂ O	N ₂ Mg
Plots receiving only Inorganics							
N ₁ P ₁ K ₁ O		N ₂ P ₂ K ₂ Mg		N ₂ P ₂ K ₂ Mg		N ₁ P ₁ K ₁ O	
K ₁ P ₂	K ₂ P ₂	K ₂ P ₁	K ₂ P ₁	K ₂ P ₁	K ₂ P ₁	K ₁ P ₁	K ₂ P ₂
N ₂ O	N ₁ O	N ₂ Mg	N ₂ O	N ₁ O	N ₁ Mg	N ₂ O	N ₂ Mg
K ₂ P ₂	K ₁ P ₂	K ₁ P ₁	K ₁ P ₁	K ₁ P ₂	K ₁ P ₂	K ₁ P ₁	K ₂ P ₂
N ₁ Mg	N ₂ Mg	N ₁ Mg	N ₁ O	N ₁ O	N ₁ Mg	N ₂ Mg	N ₂ O
Block 4				Block 3			

MANURIAL TREATMENTS

Up to, and including, 1953, the basic ("low level") treatment was 300 lb. N, 200 lb. P₂O₅ and 200 lb. K₂O per acre—treatments

N₁, P, and K₁. The excess or "high level" dressings applied were 400 lb. N, 500 lb. P₂O₅ and 400 lb. K₂O per acre—treatments N₂, P₂ and K₂. These nutrients were supplied partly as dung and partly as inorganic fertilizers, the allowance made for the N, P and K in the dung being based on analysis of samples taken from the dung used in each year. This meant that the amounts of inorganic fertilizers applied varied somewhat in each year, but the average quantities given are set out below:

N₁ 10 cwt. per acre nitrochalk—to give with dung 300 lb. N per acre.

N₂ 16 cwt. per acre nitrochalk—to give with dung 400 lb. N per acre.

P₁ 5 cwt. per acre superphosphate—to give with dung 200 lb. P₂O₅ per acre.

P₂ 20 cwt. per acre superphosphate—to give with dung 500 lb. P₂O₅ per acre.

K₁ 1.5 cwt. per acre muriate of potash—to give with dung 200 lb. K₂O per acre.

K₂ 4.5 cwt. per acre muriate of potash—to give with dung 400 lb. K₂O per acre.

A further treatment tested was presence and absence of magnesium (55 lb. Mg per acre applied as 5 cwt. Epsom salts per acre, and NIL)—treatments Mg and O. In addition, the experiment was designed to give a broad comparison between "Dung and inorganics" and "complete inorganics" treatments over three "main plots".

In 1954 the treatments were revised, partly because of the difficulty of assessing the availability of the nutrients in dung and partly in the light of information obtained from the experiment over the years 1951-53 and discussed later in this paper. The revised treatments were 14 tons dung per acre (as before), with the following applications of inorganic fertilizers given irrespective of the nutrients in the dung:

N₁ 8 cwt. per acre nitro-chalk—to give 140 lb. N per acre without dung.

N₂ 15 cwt. per acre nitro-chalk—to give 260 lb. N per acre without dung.

P₁ 10 cwt. per acre superphosphate—to give 200 lb. P₂O₅ per acre without dung.
P₂ no phosphate

K₁ 3 cwt. per acre muriate of potash—to give 200 lb. K₂O per acre without dung.

K₂ 6 cwt. per acre muriate of potash—to give 400 lb. K₂O per acre without dung.

O no magnesium

Mg 5 cwt. per acre Epsom Salts—to give 55 lb. Mg per acre without dung.

FIELD DATA

1951

The crop harvested from the plots was excellent and averaged 27.8 cwt. per acre, compared with 22 cwt. per acre for the rest of the garden, treated commercially. The main treatments effects were a *depression* in yield of 1.2 cwt. per acre associated with the high N treatment, an *increase* of 2.9 cwt. per acre due to the high P

treatment, and an increase of 1.9 cwt. per acre with high K. Only the phosphate effect was statistically significant. There was no significant effect of treatments on the dry matter content of the cones.

The phosphate effect was surprising, and contrary to expectations, and may partly be explained by the fact that the soil was initially "very low" in available phosphate, coupled with high soil fixation of applied phosphate. In addition, the hops were only planted in 1949 and 1951 was the first year of full bearing, so that the effect of phosphate on root development would be expected to be at its maximum.

1952

Adverse seasonal conditions affected the crop and the yield from the plots showed a marked fall, averaging 13.4 cwt. per acre. In this year the high phosphate was associated with a significant decrease in dry matter content of the cones, with the result that a significant increase in yield of *green* hops due to high phosphate treatment was appreciably reduced and rendered non-significant when considered in terms of *dry* hops. In terms of dry hops, high level phosphorus, potassium and magnesium all increased yields by approximately 1 cwt. per acre, while high nitrogen decreased the yield by the same amount, but none of these effects was statistically significant. The phosphate effect was considerably lower than that found in 1951 and the magnesium effect appreciably greater.

1953

The average yield of dry hops (13.2 cwt.) was similar to that obtained in 1952. In this year high nitrogen had no influence on yield, but high phosphate gave an increase of 1 cwt./acre, similar to that obtained in 1952. In contrast to 1952, high potash only gave a slight increase in yield (0.2 cwt.), and applied magnesium actually gave a depression in yield (0.6 cwt.).

None of the yield effects found were *statistically* significant, and none of the applied treatments had any significant effect on the dry matter of the cones.

1954

In this year, owing to a severe late attack of downy mildew, the crop was considerably reduced, but the plots were harvested and

gave a mean yield of dry hops of 9 cwt. per acre. As stated above, the manurial treatments applied this year were altered from those given in the years 1951-53. The main effects of treatments were small, but the higher level of nitrogen gave an increase of 0.8 cwt./acre and an increase of 0.5 cwt. per acre was associated with the phosphate treatment. It will be noted that in this year the P_2 treatment actually received no applied phosphate, so that the hops on these plots were drawing on the reserves of available phosphate in the soil built up by the heavy annual applications of phosphate given over a period of five years. The high level (K_2) potash treatment and the magnesium (Mg) treatment both gave very small increases in yield, but a big response of 2 cwt. dry hops per acre was associated with the NPMg interaction; this latter was the only statistically significant effect found. As in 1951 and 1953, applied treatments had no significant effects on the dry matter of the cones.

RECORDS OF VISUAL OBSERVATIONS

Records were taken throughout the growing season, in each year, and in general the growth pattern supported the results subsequently obtained from crop yields at harvest time. For example, 1952 was a year in which magnesium deficiency symptoms were most pronounced, and it was in this year that applied magnesium gave the maximum response of 1 cwt. per acre dry hops. The high level (P_2) phosphate treatment has always been associated with somewhat better and more vigorous growth, and this has been reflected in the yield data at the end of the season.

A feature observed every year when making visual records, has been the prevalence of potash deficiency symptoms which have been controlled, in some measure, by the high level (K_2) treatment. Nevertheless, a disappointing feature of the experiment has been the relatively poor control of potash deficiency even by heavy applications of potash fertilizers.

LEAF ANALYSIS

In 1951 and 1952 leaf samples were taken at the end of June or beginning of July, and again in August. In 1953 and 1954 only one series of samples was taken in each year, in the June/July period. Analysis has generally shown statistically significant increases in N, P, K and Mg with the high level applications of the corresponding fertilizers, but the importance of these increases should not be over emphasized. It would appear that in most years

the uniformity of the material is such that very small differences can attain statistical significance.

Nevertheless, leaf analysis has been of value in showing, in certain years, a definite increase in the calcium content of the plant with the high level phosphate applications. There is evidence that this high calcium intake may restrict the potassium intake.

SOIL ANALYSIS

Soil samples have been taken in each year and analysed by quick test methods for available phosphorus, potassium, magnesium. While, as would be expected, the results have shown increases in available nutrients from the applications of fertilizers, the important point brought out is the slow rate of build up of nutrients achieved, even with extremely heavy applications.

RESIN ANALYSIS

Samples of hop cones were taken from each plot in each year and analysed by the method of Ford and Tait. Both alpha resin and Total Soft Resin contents were determined in 1951 and 1952, but the only significant effects found were in alpha resin, in 1951; these were very small differences associated with interaction effects. In 1953 and 1954 only Total Soft Resin determinations were carried out and in these years certain significant effects were found, the main ones being increases in resin with high potash and decreases with high nitrogen; again, however, the differences were small, the maximum effect being an increase of 0.8 per cent. with high potash in 1953.

DISCUSSION OF THE RESULTS FOR THE YEARS 1951-54

The striking feature has been the marked response in yield to heavy applications of superphosphate. Soil analysis throws some light on this in that starting at very low levels of available phosphate in the soil, the low level phosphate treatment (P_1) which over the period 1951-53 averaged 5 cwt. per acre superphosphate (plus dung) per annum, had only built up the available phosphate to "medium" to "medium high" levels in the soil by the end of 1952, and to "medium high" to "high" levels by the end of 1953. Even with the heavy (P_2) applications of superphosphate, averaging 20 cwt. per acre superphosphate (+ dung) annually, the available phosphate was not at the "very high" level on all the P_2 plots by the end of 1953. It was evident, therefore, at this stage in the experiment that

the phosphate response was still being conditioned by the level of available phosphate in the soils, and that one of the objects of the experiment, namely, the study of the effects of excessive phosphate applications on soil very high in available phosphate, had not yet been achieved.

By 1953, however, the increased response to the high level phosphate application was becoming less, and evidence from the series of plots receiving only inorganic manuring suggested that 10 cwt. per acre superphosphate was a suitable application to give until the available phosphate was built up to "high" to "very high" levels. In consequence, it was decided to recast the manurial treatments applied to the plots in 1954 and to make the P_1 treatment 10 cwt. per acre superphosphate, irrespective of the phosphate content of the dung applied, and to give no phosphate at all to the P_2 plots.

The response to the high (K_2) level of potash, which was marked in 1951, showed a rapid falling off up to 1953. The rate of build up of available potash was slower than in the case of available phosphate with not such a marked difference between the K_1 and K_2 levels (averaging $1\frac{1}{2}$ and $4\frac{1}{2}$ cwt. per acre muriate of potash (60 per cent.) respectively). This may account for the lower response to potash, as compared with phosphate. It is also noteworthy that even with the K_2 applications the available potash had reached the "very high" level on only two of the sixteen plots receiving this treatment, by the end of 1953. In consequence, in 1954, it was decided to increase the potash applications to 3 and 6 cwt. per acre respectively for the K_1 and K_2 treatments and, as in the case of phosphate, irrespective of the potash content of the dung applied.

In the case of nitrogen and magnesium it was decided, in 1954, to maintain the treatments at approximately the same levels as in previous years, the N_1 level of nitrogen being considered to be a suitable level for Fuggle hops and the N_2 level representing a considerable excess. The magnesium treatment is simply concerned with the presence or absence of this nutrient.

CONCLUSIONS

The results of this trial to date have shown the importance of generous phosphatic manuring where a young plant of hops is being established on a soil low in available phosphate. As the plant becomes established, however, and the level of available phosphate is built up, the importance of phosphatic manuring decreases.

On a soil low in available potash, the dominant factor in the nutrition of the hop is potash deficiency, and what would ordinarily be regarded as generous levels of potash manuring do not control the trouble. The value of even higher dressings of potash manures is a problem for further investigation and potash fixation in the High Weald soils is a factor of importance concerned with the problem. It is evident that there are also factors, not as yet fully understood, controlling the uptake of potassium into the hop plant; in this connection there is an indication that heavy phosphatic manuring with the commonly used fertilizers, all of which are calcium compounds, may so increase the calcium content of the plant that potassium uptake is adversely affected.

The experiment has shown that, as would be expected, seasonal conditions have an important bearing on the level of nitrogen manuring to be adopted, but that in general, increasing the level of nitrogen above that currently recommended by Wye, tends to depress yield.

Seasonal conditions also have a marked influence on the incidence of magnesium deficiency and appreciable response to applied magnesium in this trial has only been found when severe symptoms of the deficiency have shown up relatively early in the season.

Both soil analysis and leaf analysis have been of value in showing up the effects of applied fertilizer treatments, but the data obtained to date cannot be considered to be sufficiently critical to translate into terms of precise manurial requirements.

No evidence has been found that manuring has any marked effect on the resin content of the hop cones. The results obtained have shown seasonal variations, but in general the main trends have been an increase in resins content with high potash manuring and a decrease with high nitrogen manuring.

The results from the plots receiving only inorganic fertilizers have not been discussed in detail in this paper, but it may be said that the mean yields over the years 1951-54 have differed very little from the mean yields obtained from the "dung + inorganics" plots. This effect may persist for some years, but it is to be expected that as the organic matter in the soil falls, the beneficial effect of dung will become evident.

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EXAMINATION OF THE ORGANIC CONSTITUENTS OF HOP PLANTS

E. W. WESTON

METHOD OF ANALYSIS

The chemical examination of the organic constituents of the hop plant in this laboratory is based upon a method used by Bradfield and Flood (1950) in their examination of fruit trees.

Their method involves the extraction of the plant material with 80 per cent. methanol, followed by evaporation of the methanol extract, leaving an insoluble chlorophyll material and an aqueous solution. The aqueous solution is filtered off and extracted with ethyl acetate. The remaining aqueous extract is passed successively through a base exchange resin and an acid exchange resin, the resulting solution containing only neutral compounds. The acidic and basic substances are removed from their respective resins by means of hydrochloric acid and ammonia.

This fractionation of the compounds originally extracted into an 80 per cent. methyl alcohol solvent, resulted in

- (a) chlorophyll fraction—insoluble in water;
- (b) aromatic fraction—extracted from aqueous solution by ethyl acetate;
- (c) acidic fraction—inorganic and organic acids;
- (d) basic fraction—amino-acids and inorganic bases;
- (e) neutral fraction—mainly sugars.

Each of these fractions, except the first, was then concentrated, and a spot applied near the top of a large filter paper. By allowing a suitable solvent to flow down the paper the fractions were resolved into their constituents, each constituent appearing as a spot, at a distance from the starting point which is a characteristic of that substance. The spots were shown up either by spraying with a reagent to give a strong colour, or by viewing the paper under an ultra-violet lamp, when coloured fluorescence spots were seen.

Originally, dried and powdered plant materials were used, but later it was considered better to use the fresh material which was macerated mechanically under pure methyl alcohol, the proportions

of plant material and alcohol being adjusted to give a final solution of approximately 80 per cent. alcohol. The plant material was filtered and washed with 80 per cent. methanol until all trace of colour had been removed.

A further modification was that the chlorophyll fraction, which incidentally, included the hop resins when hop cones were extracted, was removed by extracting the methyl alcohol solution with petroleum ether. This was considered an improvement on the previous method, since it gave much lighter coloured solutions and therefore probably less decomposition of the more sensitive substances.

By carrying out these analyses with standard weights of plant material, and by making up the final solution, before spotting on the paper, to a standard volume, the method gave roughly quantitative results.

Various parts of the hop plant were examined by this method, i.e. roots, bines, leaves and hop cones, and compared with one another for several varieties of hop during the summers of 1953 and 1954.

Samples of bine, leaves and cone were also examined in the case of one variety (Pride of Kent) at weekly intervals during the period covering the formation of the cones.

RESULTS

(1) QUALITATIVE

(a) *Chlorophyll fraction*

This fraction has not yet been examined.

(b) *Aromatic fraction*

The ethyl acetate extract seemed the most interesting and was examined in most detail. It consisted chiefly of aromatic substances.

The main feature of the chromatograms obtained from different varieties lay in the yellow spots obtained. In some varieties there were only two main yellow spots, but in others there were three or even four. The sizes of the spots also varied from one variety to another. The difference in the number which were detected may have been due to the fact that there was considerable overlapping of other spots and subsequent masking of the weaker spots.

On fuming with ammonia the yellow spots showed up under the ultra-violet lamp as yellow to orange fluorescent spots. This treatment also intensified their natural yellow colour as seen in daylight. On spraying the paper with ferric chloride the spots gave

a dark green colour, and on spraying with a solution of diazotized p-nitraniline an orange red colour was produced. In addition, ammoniacal silver nitrate was reduced when sprayed on the paper and a mixture of ferric chloride and potassium ferricyanide gave a deep blue colour. These reactions seem to indicate that the spots were due to anthoxanthins.

In addition to the yellow spots there were a number of blue and green fluorescing spots which in some cases appeared to have a slight yellow colour in daylight.

The aromatic fraction of the leaves was very much greater than either that of the stem or the hop cones themselves. However, the chromatograms obtained from the leaves in the early part of the season showed much stronger yellow spots than did those obtained during the period when the hop cones were forming. In fact the yellow spots on the leaf chromatograms at this time of the season were very little stronger than those on the hop chromatograms. The chromatograms obtained from the hop bine were always much weaker than those from the leaves at all times of the year, but otherwise were similar in general pattern.

As the size of the yellow spots diminished during the season so there was an increase in the size of a number of green fluorescing spots. These green spots overlapped each other and also one of the yellow spots so that the chromatogram became a little confused. The overlapping spots could be resolved, however, by running another solvent at right angles to the first. Only a few of these two-way chromatograms were made, owing to the fact that they were too time-consuming when fresh material was being handled over a short season. A number of overlapping blue fluorescent spots were resolved in a similar manner. They occurred nearer the solvent front with the original solvent.

On storing the chromatograms from the hop cones for some weeks it was noticed that a brown streak developed over the whole of the chromatogram. This was possibly caused by leuco-anthocyanins and may be responsible for the blurred outline of many of the spots in the later part of the season.

As the hop ripened there was a very prominent yellow spot a short distance from the solvent front which did not fluoresce, but which changed to a deeper yellow on fuming with ammonia. This spot could possibly be a component of the hop resins which is not soluble in petroleum ether.

The ethyl acetate extract from a hop root gave two well-defined spots which were coloured blue-grey by spraying with ferric

chloride and may be due to pyrogallol tannins or related substances. Two much weaker spots were obtained from the ethyl acetate fraction of hop shoots which also gave a blue grey colour with ferric chloride, but they were not identical with those obtained from the root, since they remained much nearer to the starting point.

(c) *Acidic fraction*

The acidic fraction of the hop extracts gave a chromatogram in which some 6-8 acid spots could be shown up quite readily by spraying with an acid-base indicator. These spots could also be shown by spraying with ammoniacal silver nitrate or with ferric chloride solutions.

Towards the end of the season several very pronounced blue and green fluorescing spots developed in this fraction and paralleled the similar increase in the aromatic fraction. Some of these spots may, indeed, have been due to incomplete extraction by ethyl acetate.

No very great difference was evident between different varieties in their acid constituents.

(d) *Basic fraction*

The chromatograms from the basic fraction were sprayed with solutions of ninhydrin to show up the amino acids as purple spots. As in the case of the acid fraction there was very little difference between different varieties of hop and again there was an increase in the size of several blue fluorescing spots near the solvent front. On a two-way chromatogram some of the amino acids could be tentatively identified, leucine in particular, which was the fastest running spot in the particular solvent used. Leucine and valine were confirmed by running another chromatogram together with a standard mixture of these two amino acids.

(e) *Neutral fraction*

The neutral fraction gave three spots which could be shown up by spraying with suitable reagents. These spots corresponded to glucose, fructose and sucrose. A further spot may have been raffinose, but this was not confirmed. While there were differences in the sizes of spots these did not appear to be correlated with variety or season.

(2) QUANTITATIVE

In addition to this general examination of the hop constituents preliminary investigation was carried out with a view to obtaining a more quantitative analysis of some of the components; In particular the yellow pigments of the aromatic fraction, and also the pyrogallol tannins, which were presumed to be present by reason of the blue colour obtained with certain extracts on addition of ferric chloride. Difficulties arose in both these cases owing to their inefficient extraction from the plant material. *in/*

Valine and leucine were estimated by extracting the spots from a paper chromatogram and developing a purple colour with ninhydrin. These colours were then matched with standard solutions of these amino acids treated similarly.

The separation of some of the components of the ethyl acetate fraction was carried out on a larger scale by applying a large number of spots of the extract along the starting line of a paper chromatogram. On running a solvent down the paper the components resolved themselves into transverse strips. These strips were cut out and the substance eluted by aqueous methanol.

In many cases the eluted substance was fairly pure, as shown by its forming a single spot when chromatographed again, but in some cases adjacent spots were present too, or even widely separated ones which had evidently been carried down the paper to some extent on the original chromatogram.

In most cases, evaporation of the eluate led to a gummy residue which failed to crystallize even after long standing. However, one green fluorescing spot gave a small quantity of yellow crystals, but not sufficient for further purification.

Further work in this direction, it is hoped, will provide sufficient material for identification.

* SUMMARY

Paper chromatography has been used to survey qualitatively the chemical components of the hop plant. The existence of a large number of compounds has been shown, but the precise chemical identity of most of these is as yet unknown. This technique has also been used to make a rough quantitative assessment of the incidence of these compounds. More precise quantitative measurements have been attempted in a few cases, and efforts have been made to isolate some of the substances.

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NOTES ON CURRENT RESEARCH INTO HOP DRYING

G. A. WATSON

SOME RECENT RESULTS

Since the publication of last year's report (Watson, 1954a), preliminary details of the brewing trials on the 1953 experimentally dried hops have been received from the Brewing Industry Research Foundation. These results, which will in due course be published, indicate that the use of high air speed conditions as described in the 1953 report had no adverse effect on the flavour characteristics of the hops. Indeed, some samples dried in four to six hours were accorded a higher brewing value than control hops dried under normal conditions in 12 to 14 hours.

Experiments based on this preliminary information, further investigating the use of rapid drying conditions, have been carried out on the 1954 crop. Market valuation of the resulting samples has shown once again that the use of high air speeds of up to 60 ft. per min., together with high constant temperatures of up to 160° F., can dry hops in times as short as four hours, without apparent adverse effect upon valuation. Chemical analysis of the samples shows that the Preservative Value is also unaffected.

RAPID DRYING: POINTS FOR CONSIDERATION

In mentioning these results it may be well to review the reasons for commencing this study of rapid drying conditions. There are two main reasons, the first being the necessity of assessing the effect of overdrying on the hop "petal", whether it be on the whole hop or when separated. The second is the desirability of studying drying conditions which might offer substantial advantages over conventional practice.

The first of these effects will be discussed in a later report when all brewing trial results are available. From valuation results, however, it can be said that the use of rapid drying conditions such as those mentioned above and incorporating the modified sulphuring

treatment suggested below appear to have had no appreciable effect upon the brightness, rub and aroma of samples when compared with samples dried under normal conditions. Such conditions might, therefore, be used with safety in commercial drying and their application deserves serious consideration when kiln modifications and construction are undertaken.

Under normal conditions of drying (30 ft. per min. air speed with approximate temperatures of 110° F., rising to 150°), a 2-ft. deep load of Fuggle hops takes approximately 10 to 11 hours to dry. With an air speed of 40 ft. per min. and an initial temperature of 130° F., rising to 160° F. in 2 hours, this time of drying could be reduced to between 8 and 9 hours; if an air speed of 60 ft. per min., with a constant temperature of 160° F. were used, the load would be dried in about 6 hours. These shortened times of drying would have obvious effects on kiln capacity and may be attractive to growers who find that kiln capacity limits their rate of picking. An alternative method of taking advantage of high air speeds to increase the kiln capacity is, of course, to load more deeply. However, there is a limit to the depth of hops which can be loaded evenly, particularly with machine-picked hops, and in order to achieve the enhanced brewing quality mentioned above, the loading should be kept as light as possible.

There are, however, several difficulties which must be faced if the use of these conditions is contemplated. The high capacity fans required to give high air speeds with a normal kiln floor area are expensive; e.g. to install a fan giving 40 ft. per min. through a kiln with 400 sq. ft. of floor area might involve a price difference of up to £100 when compared with a fan giving 30 ft. per min. Another point is that high air speeds would be less economical towards the end of this drying period than would a low air speed, and to counter this some device for varying the air speed or some system of recirculation might seem desirable.

The use of high air speeds would also require that greater attention be paid to the efficient mixing of the inlet hot and cold air streams, and with oil firing, large-capacity or multiple jets might need to be used. It is difficult to see how these high air speeds could be used with open fires, due to the danger of flying ash and sparks. It has been found that flying sparks may be a danger even with a normal oil-fired kiln, for dust is caught up in the air flow, ignited in the furnace and whirled up to the roof of the plenum chamber with consequent risk of fire in the wooden slats of the kiln floor.

A further difficulty lies in the sulphuring of the hops. Under normal conditions the burning sulphur fumes will pass through the hop load for up to an hour; for some time after this the sulphur dioxide absorbed by the hops may continue its bleaching action as a large proportion of the hop load will remain appreciably moist for up to 3 to 4 hours. However, in the rapid drying of hops, even if the sulphur fumes pass for an hour, the loss of moisture is so rapid, particularly in the lower layers of the load, that complete bleaching may not be obtained. Resulting samples are likely to be green in comparison with normally dried samples, particularly if the hops are under-ripe. This effect must be countered by either using greater amounts of sulphur or by carrying out the sulphuring at a comparatively low air speed before the rapid drying conditions are imposed.

EQUIPMENT FOR RAPID DRYING

The introduction of rapid drying facilities may mean much more than the simple installation of a large fan in an existing kiln. It is convenient to consider the problems involved under two headings:

(a) *Use of air speeds of up to 40 ft. per min.*

Where kiln speeds of from 20 to 30 ft. per min. are found to be inadequate, the provision of heater and fan units giving air speeds of up to 40 ft. per min. will generally be a fairly simple operation. Such an installation should involve no major reconstruction for a conventional kiln and should be justified by increased drying capacity.

(b) *Use of air speeds of more than 40 ft. per min.*

The use of air speeds in excess of 40 ft. per min. requires careful consideration of the points set out in the previous section. It may well be found that rather than modify existing kilns at considerable expense to use such conditions, it may prove more satisfactory to move into the field of very high air speeds of perhaps 80 to 100 ft. per min. This can best be done on a continuous drying system, recirculating the hot exhaust air from the later stages of the drying through the incoming green hops. Such a system has been tried experimentally in the U.S.A. (the *Brewer's Digest*, 1954, p. 66) using air speeds of between 150 and 250 ft. per min. at temperatures between 170° F. and 240° F., hops being dried in under 50 min. Before these conditions could be recommended here an extended

study of their effect upon hop quality would need to be undertaken, but it is of interest to observe the lines of development in drying in that country. Preliminary calculations have shown that with an air speed of between 80 and 100 ft. per min. and a temperature of 160° F., a continuous dryer dealing with the output of one Medium Bruff picker would require a belt 50-60 ft. long, 6 ft. wide and a loading depth of 24 in.

INSTRUMENT FOR DETERMINATION OF END OF DRYING

In last year's Report the use of a thermometer to assess the end-of-drying time of a hop load was suggested. Further experiments in connection with this were carried out in 1954 and encouraging results were obtained. The thermometer used was a flexible wire-covered cable 4 ft. long, containing a temperature-variable electrical resistance element connected to a battery-powered indicating instrument. This element was laid on top of the hop load and readings of the temperature were taken at intervals during the drying period. It was found that this temperature remained steady during the initial stages of drying and then proceeded to rise gradually until at the end of drying it was within 5° of the inlet temperature of approximately 150° F. The actual temperature difference depended largely upon the relative humidity of the inlet air, but as the rate of increase of temperature was practically nil when the hop load had reached a satisfactory condition, the end-of-drying time could be quite easily recorded.

This type of thermometer has distinct advantages over those of the more conventional type; the element can be made in lengths up to 50 ft., thus ensuring that the conditions over a large proportion of the load are measured, and not merely those in the neighbourhood of a small bulb; the elements can be easily stored away when not in use, and with present indicating instruments, up to six elements can be connected up to and read separately on one remote central instrument.

Although dryers may still prefer to test with their hands in deciding when to take the hops off, the advantages of possessing an instrument which can indicate the condition of a load of hops at any moment are obvious. One very significant advantage is that if data are collected on ambient temperature and humidity, inlet temperature and exhaust temperature, with each load of hops, the dryer will be in a position to take hops off at a more uniform condition than hitherto.

COOLING OF HOPS AFTER DRYING

A field of work in which little study has so far been possible is that of the conditions governing the cooling of the hops. An experiment mentioned in last year's Report and since described in detail (Watson, 1954b), gives an account of some of the factors concerned. Nevertheless, the operation is so affected by the individual conditions of each load that its success still depends on the skill and experience of the dryer rather than on the application of scientific knowledge. However, the use of devices such as the thermometer described above should enable hops to be taken off the kiln under more standard conditions than hitherto, and so minimize the after-care that seems to be so often necessary.

PRESSURES DEVELOPED UNDER HOP LOADS DURING DRYING

Another experiment carried out in the 1954 season, with Mr. Pearce, Farm Machinery Officer, South East Province, N.A.A.S., was to measure the water-pressures developed under comparable loads of hand-picked and machine-picked hops. Only minor differences were found; at 30 ft. per min. air speed, pressures were not quite 0.20 in. under approximately 24 in. deep loads of hops; at 60 ft. per min. there was a pressure of 0.54 in. under a 24-in. load of machine-picked hops, and of 0.49 in. under 20 in. of hand-picked hops. The detailed data from the experiment are intended to provide information on the fan performance required for any given conditions.

ACKNOWLEDGMENTS

Thanks are due to Lieut.-Col. F. N. Richardson and Mr. A. E. Quin for carrying out the commercial valuation of samples referred to in these notes.

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ROSEMAUND EXPERIMENTAL HUSBANDRY FARM

HOP EXPERIMENTS. PROGRESS REPORT I

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Though the largest acreage of hops in the country is situated in the South East, over 6,000 acres or approximately one-third of the total acreage grown, is located in the West Midland counties of Hereford and Worcester. Until recently, however, there has been no experimental centre for hop investigations in the West Midlands, and while hop research has been carried out at Wye College, in Kent, for many years, such research has inevitably tended to be more concerned with conditions operating in the South East. In December, 1949, under the scheme of the then Ministry of Agriculture and Fisheries for the establishment of experimental husbandry farms throughout the country, the Rosemaund Farm at Preston Wynne, near Hereford, was acquired. This farm already carried 39 acres of hops, and it was decided to continue growing hops and to lay down hop experiments.

The local climatic conditions at Rosemaund and Wye vary. While the annual and seasonal figures for rainfall and air temperature do not differ greatly, calculations by the Meteorological Office by Penman's (1) method show that the loss of water by a growing crop during the summer months increases from a line Humber to Bristol Channel towards the South and East of the country, being the highest in the area of the Thames estuary. Records of soil temperatures at Rosemaund and Wye show that for the three months of June, July and August, the average soil temperature at depths of 4 in., 8 in. and 2 ft., is several degrees warmer at Wye than at Rosemaund. This may be influenced by the fact that the Wye area

has appreciably more sunshine than the Rosemaund area, and such factors may account for the later ripening of the crop in the latter area.

In view of the incidence of virus disease, more particularly nettlehead and split leaf blotch, and of other complicating factors, it was decided not to use the existing hop yards, but to establish new yards as necessary for experimental purposes. The first series of experiments has been laid down in Slade field. There is no record of hops having been previously grown on this field which, despite the slightly exposed situation, was selected as the most suitable new hop ground on the farm. This area had been permanent grass for many years and, so far as is known, had never been ploughed until broken up in 1939 and subsequently cropped for three years with cereals followed by seven years in ley and a further two years of cereal cropping before being planted to hops in the autumn of 1951 and the spring of 1952.

Records of the hop crop yields were first taken in 1953 on those experiments which were planted with rooted sets; on the remaining experiments, planted with layer cuttings, yield data could not be obtained until 1954.

While a number of people were concerned with the organization of the first series of experiments laid down in Slade Yard, the main responsibility for selection of the hop yard and planning of the work was undertaken by Dr. A. H. Burgess, the then Head of the Department of Hop Research at Wye, and a close link between Wye and Rosemaund was thus established at the outset.

At the present time, the consideration of all new experimental projects in hops and the co-ordination of work planned for both Wye and Rosemaund is undertaken by a Hops Working Party which makes recommendations to the Horticultural Experiments Committee of the Agricultural Improvement Council. The Chairman of the Working Party is Mr. H. S. Darling, Head of the Department of Hop Research, Wye College, and the Secretary is Mr. W. F. Cheal, Rosemaund Experimental Husbandry Farm. The other members of the Working Party are:

Mr. G. P. Chater, Hops Advisory Officer, West Midlands
Province, N.A.A.S.

Dr. H. H. Glasscock, Plant Pathologist, Wye Sub-Centre,
N.A.A.S.

Miss C. L. Jary, Hops Advisory Officer, South-East Pro-
vince, N.A.A.S., Wye Sub-Centre.

- Mr. E. L. Jones, Director, Rosemaund Experimental Husbandry Farm.
- Mr. J. O. Jones, Advisory Soil Chemist, West Midlands Province, N.A.A.S.
- Mr. F. C. Thompson, Department of Hop Research, Wye College.

Members of the Working Party are in touch with the problems of the hop industry and are able to draw on their own experience as well as the suggestions of various organizations and individual hop growers, when putting forward proposals for further experimentation.

Preliminary results from the first experiments are now becoming available, but it was felt that it would be unwise to discuss them in this paper. As soon as sufficient evidence is available, progress reports will be issued. The object of this report is primarily to describe the purpose and design of the experiments which have recently been laid down in Slade Yard at Rosemaund.

SLADE HOP YARD

The soil in this yard is generally uniform for the district and is a sandy clay loam of the Bromyard series, derived from the Old Red Sandstone (2). There are five experiments, all planted with clonal Fuggle "N" stock, and an observation trial of the new (Wye) varieties. Further, with the exception of a manurial trial, the experiments all receive the same standard fertilizer treatment.

Experiment No. 1

Comparison of Row and Square Planting.

The row planting is 7 ft. 3 in. between the rows and 3 ft. 6 in. between plants, a spacing commonly adopted under the predominantly "Worcester" work system of the West Midlands. The square planting is 7 ft. 3 in. by 7 ft. This is a somewhat larger spacing than is commonly used under the "Kent" work of the South-Eastern hop growing area, but the arrangement provides for each "string" to have the same area of land under both systems of planting.

The object of this experiment is to test, under the climatic conditions of the West Midlands, the yield and quality of hops when grown in rows and on the "square".

Experiment No. 2

Cultivations Experiment.

This experiment was designed to study the effect of time of cessation of deep cultivation, on hop yield. The trial was planned by Dr. A. H. Burgess to test out under the soil and climatic conditions at Rosemaund, the effects of certain cultivation treatments which he had studied at Wye over the period 1930-48, and which he found had no statistically significant effects on yield (3). Percival (4) at Wye, was the first person to draw attention to the fact that hops in an experiment at Goudhurst, Kent, which received no deep cultivation, cropped as well as those receiving conventional cultivations, and Burgess's experiment confirmed these observations. The soil at Wye, on the Brices series, is a deep brick earth very different from the heavier Old Red Sandstone soil at Rosemaund, which may possibly behave differently.

The treatments tested are:

- (a) No deep cultivation; i.e. land ploughed 6 in. deep in spring and subsequently cultivated to a depth of 3 in. only when necessary to keep down weeds.
- (b) One deep cultivation after ploughing in spring; i.e. the land ploughed to a depth of 6 in. and followed with one cultivation to the same depth.
- (c) Deep cultivations to cease when bines reach top wire.
- (d) Deep cultivations to cease when cones have just formed.

After the cessation of "deep" cultivations, i.e. to 6 in., any further cultivations necessary, to keep down weeds, are carried out to a depth of 3 in.

It is still common practice to carry out frequent deep cultivations in hops throughout the growing season, but the value of such cultivations is a matter of opinion, and it is considered by some workers that the frequent destruction of surface rootlets entailed may adversely effect nutrient uptake from the surface soil and so restrict plant growth. It is hoped that this experiment will throw some light on this controversial problem.

Experiment No. 3

Manurial trial.

The treatments tested in this experiment are four levels of nitrogen, two levels of phosphate, four levels of potash, and two levels of magnesium. All plots receive a uniform dressing of shoddy

annually, calculated to supply 100 lb. nitrogen per acre, with the object of maintaining the humus content of the soil. The levels of nutrients applied, as inorganic fertilizers, in addition to the shoddy are:

Nitrogen: Nil, 80 lb., 160 lb., 240 lb., N per acre.
 Potash: Nil, 100 lb., 200 lb., 300 lb., K_2O per acre.
 Phosphate: Nil, 250 lb., P_2O_5 per acre.
 Magnesium: Nil, 100 lb., MgO per acre.

The fertilizers used are sulphate of ammonia, sulphate of potash, superphosphate and magnesium sulphate. The levels of nitrogen and potash have been chosen so that the response curve for these fertilizers can be calculated; the top levels in each case are "excess" levels, appreciably above those which would be recommended in practice for soils in a good state of fertility. In the case of phosphate, only two levels of treatment were practicable within the experimental design which also incorporates two levels of magnesium treatments. The magnesium treatment has been included because it is now recognized that this nutrient can, under certain conditions, play an important part in the nutrition of the hop.

Experiment No. 4

Dressing and pulling experiment.

The treatments are dressing (cutting) of stocks (hills) each year at four different periods, i.e.

- (a) in the autumn;
- (b) in the early spring (about the end of February);
- (c) in mid-season (about the end of March);
- (d) in late spring (about mid-April);

combined with the training of bines of varying vigour, i.e.

- (1) Strong bines;
- (2) Medium bines;
- (3) Weak bines.

With regard to pulling no constant definition of strength of bine can be given, as the type of bine available will depend on seasonal and other factors, but standards are set so that strong, medium and weak bines are clearly differentiated within each season, and the standards themselves conform as nearly as practicable from season to season.

The treatments under investigation in this experiment are ones which are continually debated by growers and the trial is an attempt

to obtain some precise information on points which, at the present time, are largely matters of opinion.

Experiment No. 5

Cutting and stripping experiment.

The treatments tested in this experiment are:

- (a) to cut bines at picking time;
- (b) not to cut bines out at picking time, the bines being left to ripen off before cutting about November;

combined with the further treatments:

- | | | |
|-----|--|-------------|
| (1) | Lower leaves and laterals cleared to a height of 6 in. | |
| (2) | " " " " " " " " " | 2 ft. |
| (3) | " " " " " " " " " | 3 ft. 6 in. |
| (4) | " " " " " " " " " | 5 ft. |

The object of the bine cutting part of the experiment is to see how far cutting at picking time, as is usually practised when machine picking, weakens the plant and reduces crop. It is commonly thought that the effect is appreciable, but observations on farms where picking machines are used have suggested that this may not always be so.

Stripping the lower leaves and laterals is a precaution taken by many growers to help control of the development of the fungus diseases mould (powdery mildew) and downy mildew. How far this practice may check plant growth is the object of the second part of this experiment.

Experiment No. 6

New Variety Observation Plots

Thirteen named varieties bred by Professor Salmon at Wye, have been planted for testing in observation plots, the varieties being:

Brewer's Gold (C9a)
Bullion (Q43)
College Cluster (N15 *bis*)
Concord (OH44)
Copper Hop (OK40)
Early Choice (FF21)
Early Promise (X35)
John Ford (WFA90)
Malling Midseason (BB28)

Northern Brewer (WFB135)
 Norton Court Golding (WFG19)
 Pride of Kent (170a)
 Sunshine (V94).

Early Promise was grubbed out after the 1954 harvest on advice from the Hops Marketing Board that this variety was not required by the brewing industry.

FUTURE EXPERIMENTS

A second new hop yard (Prestons Yard) has recently been established, and it is proposed that this yard should be used for an experiment on growing hops under sward. The sward treatment is to be compared with arable cultivations, both with and without dung, and further treatments superimposed on the main treatments include a study of different seeds mixtures and the effect of different levels of nitrogenous manuring on both the sward and arable treatments.

The original plantings of hops at Rosemaund are being systematically grubbed and the most favourable sites will be replanted to hops after suitable cropping and when required for further experiments.

It will thus be seen that an extensive programme of hop experiments has already been started by the National Agricultural Advisory Service and further experiment projects will be considered in accordance with the needs of the industry. The results of these experiments will be presented as they become available in the reports from Rosemaund and in other publications of the Ministry of Agriculture, Fisheries and Food. They will also be made available for publication in this Annual Report.

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A SURVEY OF RECENT HOP RESEARCH IN COUNTRIES OUTSIDE ENGLAND

F. C. THOMPSON

A. RESEARCH IN EUROPE

Hop research in Europe is now co-ordinated by a Scientific Commission which is a sub-committee of the European Hops Cultivation Committee. At the present time the Department of Hop Research at Wye is represented on the Commission by the Head of the Department, Mr. H. S. Darling, and by Mr. F. C. Thompson. The other member countries are Belgium, France, Germany, Yugoslavia and Spain, and annual meetings have been held in the first four countries since 1951. In 1955 the Commission is to meet in England, and it has been agreed that the conference should be held at Wye under the Presidency of Mr. F. C. Thompson. At each conference there is a paper reading session and certain of the papers are subsequently published in technical journals.

In view of the forthcoming meeting of the conference in Wye in 1955, it was thought desirable to give a brief review of recent research work in member countries, and in addition to draw attention to hop research which is being developed in countries outside Europe, and particularly in the U.S.A. In spite of fluctuations in the demand for hops, hop research is being actively developed throughout the world, and while many of the experiments in progress are likely to yield results of only local application, there are certain fundamental investigations in progress which should prove of general application. Some account of research in Europe now follows:

BELGIUM

Hop research in Belgium is organized by l'Institut National Belge du Houblon. A summary report of the work of the Institute in 1953, has been published by Hoed *et al.* (1). The investigations include fertilizer trials, variety trials, plant breeding work, tests of spray materials for the control of downy mildew and aphid and red spider, the effect of slope of string (wire) on yield and resin content, and brewing trials.

While the results of many of these trials are only applicable to the conditions found in Belgium, it is of interest to note that in the variety trials a number of the New Varieties bred by Professor Salmon at Wye are being tested. Of these, Northern Brewer has received highly favourable reports and Early Promise is also liked, the latter variety, in fact, has been preferred in brewing trials to selections of the well known Continental varieties Saaz, Tettngang and Hallertau.

In collaboration with workers at l'Institut Agronomique de l'Etat à Gembloux, a fundamental investigation of the uptake of mineral nutrients by the hop plant is being undertaken. It is understood that this work is nearing completion and is soon to be published and this should be a valuable contribution of general interest to hop research workers.

FRANCE

The chief hop growing areas in France are in Burgundy and Alsace-Lorraine, and the main work on hop research is being undertaken at the Station d'Amélioration des Plantes at Dijon, Burgundy. A review of the researches carried out in 1953 has been given by Meneret (2). As in Belgium, much of the work is primarily of local interest, but a paper on the morphological characters of the hop has recently been published by Meneret *et al.* (3). These workers have studied the size of bracts in the hop cone, using measurements of the length/width ratio in an attempt to assess the value of this morphological character in distinguishing between different varieties of hop. They have found it possible to group hops into three main types; those with long, narrow bracts; those with broad, round bracts; and an intermediate group. While they regard the length/width ratio of the bracts as a useful additional diagnostic character in the identification of commercial hop varieties, they stress that it cannot be regarded as a highly specific characteristic.

Some hop research is carried out in Alsace and a brief paper of interest has been published by Marocke (4) from the Station d'Agronomie de Colmar, on the distribution of boron in the hop plant.

GERMANY

The main hop growing area in Germany is in Bavaria, particularly in the Hallertau district north of Munich. A hop experiment station was established in 1926 at Hüll, near Wolnzach, in

the heart of the Hallertau district, and a review of 25 years' work at Hüll has recently been published under the editorship of the present Technical Director of Research, Dr. F. Zattler (5).

Zattler (6) has also published an account of work carried out in 1953 and 1954. The programme has included large-scale testing of spray materials for the control of downy mildew, *Cladosporium*, aphid and red spider. Hormone sprays have been tested for general growth effects and promotion of bud and cone formation; no positive results were obtained and in some cases damage was caused. Reference is made to a new trouble—"red tip" of cones; it is thought that this may be caused by gall midges and be allied to the browning of cones reported by Theobald (7), in England, as caused by the Hop Strig maggot. Cockchafer larvae and the caterpillars of the Ghost Moth appear to be more serious pests of hops than is the case in England, and control measures are described. Various hop diseases which result in such symptoms as leaf malformation and stunted growth, are classed as physiological diseases; it is stated that virus diseases are unknown in hops in Germany. An account is given of the extensive plant breeding programme in being, with the aim of producing a downy mildew resistant hop of high quality; one of the main bottlenecks restricting the progress of such work is the lack of adequate facilities for breeding trials. Other work includes manurial and cultural trials.

Out of this big programme of investigational work an aspect of particular interest to workers in this country is the research into the production of downy mildew resistant varieties, and it is pleasant to record that some measure of collaboration has already been established between workers at Wye and at Hüll, on this important problem.

A further investigation of great interest to hop workers in this country is a study of the effect of cutting the hop vines at picking time as compared with leaving them to ripen off before cutting. As in this country, this investigation was prompted by the likely advent of machine picking into Germany. An account of these experiments has recently been published by Zattler (8) and is discussed elsewhere in this report in relation to results obtained in English experiments.

YUGOSLAVIA

A very well equipped Institute for Hop Research has recently been established at Zalec, in the Styrian hop growing district of

Slovenia, Yugoslavia. At the present time investigations are primarily concerned with local problems.

SPAIN

Hop growing in Spain is a recent introduction, and no information is available on any research activities in this country.

OTHER EUROPEAN COUNTRIES

Before the last war, the Saaz district of Czechoslovakia was one of the most important hop growing areas in Europe and a hop research institute was located in the town of Saaz. Since the war such research has doubtless continued, but little information is available.

Among other countries it is known that hop investigations are being initiated in Sweden and in Austria. In Sweden the main concern is to breed varieties which will grow and ripen under the climatic conditions found in that country. In Austria variety trials are being carried out and certain of the New (Wye) Varieties are under test, with promising results (9).

GENERAL OBSERVATIONS

As in England, machine picking is becoming a factor to be considered in hop growing in Europe. This is particularly so in Germany (10) and Czechoslovakia (11), where machines are in operation; considerable interest is also being displayed in Belgium.

Great interest is also being shown in variety trials and plant breeding work in all countries where hop research is in progress, and it is noteworthy that some of the New Varieties bred by Professor Salmon at Wye are now widely distributed at centres throughout Europe, and that certain of them are preferred to locally-established varieties.

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B. RESEARCH IN COUNTRIES OUTSIDE EUROPE U.S.A.

At the present time, apart from one or two gardens of almost historic interest in New York State, hop growing in the U.S.A. is centred on the four West Coast States of Oregon, Washington, Idaho and California. Hop research has been carried out for many years and was at one time active at the New York Experiment Station, Geneva, but is now largely concentrated at the Oregon State College, Corvallis, except for work on machine picking and hop drying which, together with some work on virus diseases, is dealt with at the Washington State College. An excellent review of the position in 1950 is given in the report of the Hop Industry Productivity Team (1) which toured the hop growing areas in the U.S.A. in that year. An outline of the quite ambitious programmes of research envisaged in 1951 can be read in papers by Vogel (2) and by Hoerner (3). While the over-production of hops and the recession in the hop trade in the U.S.A. may influence the full development of the research programme as originally planned, a recent report by Hoerner (4) indicates that the Brewing Industries Research Institute is giving active support to the work. A number of papers have appeared in technical journals in the past few years and a list of references is given below (5 to 19); it is hoped that a

review of published work and an assessment of the trends of hop research in the U.S.A. can be given in the next number of the Wye report.

OTHER COUNTRIES

A hop research station has been established in New Zealand and a programme of cultural experiments and plant breeding work has been started. Certain chemical investigations, particularly on the boron nutrition of the hop and on the development of hop resins, are being carried out at the Cawthron Institute, and papers on this work have recently appeared (20, 21).

In Canada there is a considerable acreage of hops in British Columbia and while there is no centre of hop research, occasional papers appear in the technical journals on specific problems (21).

Mention must also be made of the work on the cytology of the hop plant in progress in Japan, where, prior to the last war, the most complete studies on this important aspect of fundamental hop research had been carried out. Recent work has been concerned with sex determinations and polyploidy in hops (23).

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APPENDIX I

DETAILED NOTES ON SOME NEW VARIETIES OF HOPS IN WYE FIELD PLOTS, WYE COLLEGE

F. H. BEARD and E. S. SALMON

In this appendix, full details are given concerning the 33 new varieties of hops discussed in a paper appearing earlier in this report (9). The varieties are considered in groups as tabulated in the above paper.

Information on each variety is given under the following headings:

- (a) Yield in cwt. of dried hops per acre.
- (b) Physical (organoleptic) examination: commercial appraisal of the appearance and aroma of the dried sample.
- (c) Chemical analysis for soft resin content (preservative value).
- (d) Cultural details.
- (e) Susceptibility to downy mildew and mould disease.

VARIETIES LISTED IN TABLE 1. SEEDLINGS RAISED BY CROSSING THE CANTERBURY GOLDING WITH A MALE HOP (REF. No. OB21) RAISED FROM BREWER'S GOLD (C9a). THE FIRST GENERATION FROM CANTERBURY GOLDING.

Certain of these seedlings have already been described (2 and 3); one of them, viz. Northern Brewer (WFB135), has found considerable favour in commercial cultivation and is being grown on a steadily increasing scale. The five seedlings reviewed below have a Golding habit of growth and an aroma approximating to that of Goldings. It would be instructive if brewing trials could be carried out between these seedlings and Goldings and also Golding Varieties.

For purposes of comparison in relation to susceptibility to downy mildew disease, it is to be noted that the incidence of infection in two named varieties of the same parentage growing in the same series of plots has been as follows:

- (a) Northern Brewer (WFB135): Plot 9. Mean rate of spikes per 100 hills was 67 for the 5-year period 1950-54 with a minimum of 5 in 1950 and a maximum of 108 in 1952. Cones have remained free of disease and there has been no indication of rootstock infection.
- (b) John Ford (WFA90): Plot 2. Mean rate of spikes per 100 hills was 512 for the 5-year period 1950-54 with a minimum of 83 in 1951 and a maximum of 1,410 in 1952. The latter very high figure was due largely to the heavy incidence of lateral spikes. There was a trace of cone infection in 1950. There has been no evidence of rootstock infection.

WFI36. Plot 1.

- (a) 1945: 18.75 cwt. per acre. 1946: 15.25 cwt. 1951: 21.88 cwt. 1952: 21.60 cwt. 1953: 26.59 cwt.
- (b) 1946: "I cannot detect American aroma in WFI36 and WFA53; they are like high quality English" (Brewer). 1947: "Aroma pleasant, but not outstanding; good lupulin" (Brewer). 1953: "Aroma pleasant, nice fragrance, resins good" (Brewer). In brewing trials carried out in 1947 (Bibliography (6)) it gave in the copper hop test a very bitter, strong, slightly rank flavour, with good nose. In blend it was more agreeable. In the dry hop test it gave a "mild hop bitter and pleasant flavour".
- (c) 1945: (17.12.45) 5.91% alpha resin, 10.27% beta resins. 1946: (9.12.46) 5.86% alpha resin, 11.24% beta resins. 1953: (11.1.54) 8.40% alpha resin, 11.58% beta resins.
- (d) The parent plant in Wye Field Nursery was recorded in 1939: "Bumper" crop, "all hops"; cone of Golding type, but with more petals; all cones well developed, with no "leaves" in the cones; aroma pleasant; ripe Sept. 14th (with Cobb's). Analysis 7.09% alpha resin, 11.08% beta resins.

Plot 1: growth in the early part of the season is usually rather weak, but later develops plenty of very croppy laterals.

- (e) Only moderately liable to the spike form of the disease, with a five-year mean of 108 spikes per 100 hills, and a maximum tendency for production of late lateral spikes.

In two seasons there has been a trace of slight infection of the cones. There is some indication of a liability to rootstock infection as in most seasons there are a few weak hills, and since 1950 eight hills have died and been replanted.

WFD20. Plots 15 and 28.

- (a) 1947: 30.25 cwt. 1950: 32.20 cwt. 1951: 22.85 cwt. 1952: 16.70 cwt. 1953: 18.91 cwt.
- (b) 1947: "pleasant Golding aroma" (Merchant); 1947: "aroma pleasant, strong, slight coarseness in background, lupulin very good" (Brewer). 1948: "nice cones, pleasant aroma, rather heavy, good resin" (Brewer). 1950: "appearance good, aroma pleasant" (Brewer); 1950: "pleasant flavour of Golding type" (Merchant). 1951: "aroma pleasant, a good hop of Fuggle class" (Brewer).
- (c) 1946: (9.12.46) 5.94% alpha resin, 10.04% beta resins. 1947: (2.3.48) 6.00% alpha resin. 1948: (28.12.48) 6.72% alpha resin, 10.86% beta resins. 1950: (12.2.51) 7.58% alpha resin, 11.21% beta resins. 1951: (28.1.52) 5.32% alpha resin, 9.93% beta resins.
- (d) The parent plant in Wye Field Nursery was recorded in 1938: "good crop, Golding type of cone, dense, rich (cones opening 'golden'), aroma pleasant, ripe Sept. 5th". Several of the clone-plants in the Nursery had subsequently "bumper" crops. In *Plots 15 and 28* growth is vigorous, with ample bine at training time. There is a tendency for the production of leafy cones. Midseason.
- (e) *Plot 28* has for some reason shown a higher incidence of spikes than *Plot 15*. *Plot 28* has had a mean of 43 spikes per 100 hills, with a maximum of 64 (1951) and a minimum of 25 (1953), whilst *Plot 15* has had a mean of only 17 spikes per 100 hills, with a maximum of 50 (1953) and complete freedom in 1951. This variety appears rather more liable to terminal spikes than the others of the group, though in the main it is the least affected with basal spikes. There is no evidence of rootstock infection and the cones have not been affected.

WFD20 has been planted (1953) in a trial plot on a farm in Kent.

WFA53. Plot 18.

- (a) 1945: 17.00 cwt. 1946: 15.25 cwt. 1950: 28.63 cwt. 1951: 22.15 cwt. 1952: 17.83 cwt. 1954: 21.09 cwt.
- (b) 1938: "has a Golding appearance, not a definite Golding aroma; could be classed among English varieties" (Merchant). 1946: "I cannot detect American aroma, it is like high quality English" (Brewer). 1950: "aroma pleasant, has some Golding character" (Brewer).
- (c) 1945: (17.12.45) 4.83% alpha resin, 7.32% beta resins. 1950: (12.2.51) 5.77% alpha resin, 9.56% beta resins. 1951: (30.1.52) 3.43% alpha resin, 8.09% beta resins.
- (d) The parent plant in Wye Field Nursery was recorded in 1938: "heavy crop, cylindrical cone, many-petalled, rich, aroma pleasant". Clone-plants have been recorded as "very fruitful". Analysis, 1938: (8.11.38) 5.65% alpha resin, 9.44% beta resins. In *Plot 18* growth is of moderate vigour with croppy "tails" and no "heads". There is a tendency for leafy cones to be produced in some seasons. Early-mid-season.
- (e) Must be considered as one of the most liable to spikes, having a five-year mean of 173 spikes per 100 hills. In 1952 there were no less than 485 spikes per 100 hills, in 1951, the best season, there were only 20 spikes per 100 hills. In 1953 there was a trace of infection on the cones. It does not appear to be liable to rootstock infection.

WFI66. Plot 37.

- (a) 1947: 25.00 cwt. 1951: 25.93 cwt. 1952: 19.99 cwt.
- (b) 1947: "aroma mild, pleasant" (Merchant). 1949: "Pleasant aroma, though a little coarse" (Brewer). 1951: "aroma pleasant, not strong" (Brewer).
- (c) 1949: (16.2.50) 5.80% alpha resin, 10.40% beta resins. 1951: (30.1.52) 4.74% alpha resin, 11.43% beta resins.
- (d) The parent plant in Wye Field Nursery was recorded in 1941: "very fruitful, cone bold, dense, many-petalled, rich, shows promise".
In *Plot 37* growth vigorous, with ample bine at training time; there is a tendency for the production of leafy cones. Late.

- (e) Spike formation has increased steadily from under three spikes per 100 hills in 1950 to 151 spikes in 1954, the mean for the five-year period being 54 spikes per 100 hills. There is no indication of rootstock infection. In 1950 the cones were badly attacked.

Mould occurred on the cones in 1952 and 1954.

WFH6. Plot 10.

- (a) 1954: 18.91 cwt.
 (c) 1938: (parent plant) (10.11.38) 5.18% alpha resin, 10.53% beta resins.
 (d) The parent plant in Wye Field Nursery was recorded in 1938: "heaviest cropper, cones of Golding type, hangs well, aroma pleasant, ripe Sept. 22nd"; 1943, good crop of nice firm cones, with about the same "condition" as Canterbury Golding.

Plot 10: the hills are still immature, planting having taken place in 1951 and 1952. Hills in 1954 were still inclined to be weak and uneven, though the stronger hills appeared croppy.

- (e) Spike production for the three seasons has been at the rate of 242 (1952), 47 (1953) and 41 (1954) per 100 hills. In 1954 there was a slight attack on the cones. The plot has not been established long enough for there to be any evidence as to rootstock infection.

Summary. Of this group, WFD20 would appear to be the most promising from field observations, having vigorous growth with ample primary shoots and a relatively low downy mildew spike incidence and freedom from rootstock infection.

VARIETIES LISTED IN TABLE 2. THE SECOND GENERATION FROM CANTERBURY GOLDING. SEEDLINGS FROM OPEN POLLINATED FLOWERS OF WYE FIELD GOLDING (WFC81) AND JOHN FORD (WFA90).

OQ14 (from Wye Field Golding). Plot 8.

- (a) 1952: 18 cwt. 1953: 25.47 cwt. 1954: 20.58 cwt.
 (b) 1952: "appearance good, aroma very good, like Golding, resin very good" (Brewer). 1953: "appearance very good, aroma pleasant, resin good; the aroma is English" (Brewer).

- 1954: "aroma pleasant, mild; good Golding type aroma, resins very good" (Brewer).
- (c) 1952: (5.1.53) 7.52% alpha resin, 11.42% beta resins.
1953: (11.1.54) 6.14% alpha resins, 11.26% beta resins.
- (d) Growth is inclined to be slow-starting. In May, when the bine of most varieties is about 2 ft. high, the bine of OQ14 is only just showing and is rather sparse; later in the season, however, growth becomes very vigorous, too much so for the rather low wirework (12 ft. 9 in.) and close spacing (6 ft. square) of the Wye Field Plots. Pollination has been poor, so that yields are likely to be lower than they should be. This variety is Midseason-Late, and very fruitful; the many-petalled cones when fully pollinated are bold and dense.
- (e) Over a three-year period spikes per 100 hills have ranged from 12 in 1952, 67 in 1953 and 2 in 1954. There has been no attack on cones in spite of rather "housed in" growth and no evidence of rootstock infection. It may be considered a satisfactory hop from the downy mildew angle. A trial plot of OQ14 has been established on a farm in Kent.

WFI94 (from Wye Field Golding). *Plot 14.*

- (a) 1947: 23.75 cwt. 1950: 23.15 cwt. 1951: 17.62 cwt.
1952: 16.08 cwt. 1954: 16.21 cwt.
- (b) 1939: "Is quite a pleasant English hop and from the point of view of aroma I should like large supplies" (Brewer).
1947: "very mild and pleasant aroma, a 'commercial winner'" (Merchant). 1949: "good appearance, pleasant aroma" (Brewer). 1950: "nice clean flavour, very mild" (Merchant); 1950: "appearance very good, has some resemblance to Goldings, but it has not the delicate nose found in Goldings" (Brewer).
- (c) 1949: (7.2.50) 5.60% alpha resin, 10.75% beta resins.
1950: (7.2.51) 5.03% alpha resin, 11.95% beta resins.
- (d) In 1939 the parent plant in Wye Field Nursery was recorded: "Bumper" crop, Golding cone, Golding aroma but stronger, rich; crops to ground, easy to pick. Ripe Sept. 14th. Analysis (8.12.39) gave 5.63% alpha resin, 12.38% beta resins.

Plot 14: growth fairly vigorous; a tendency for leafy cones to be produced. Midseason.

- (e) One of the worst for spike production, with a five-year mean of 441 spikes per 100 hills, with a maximum of 965 spikes per 100 hills in 1952. There was slight cone infection in 1952. There is also a liability to rootstock infection. An earlier planted plot (Plot 23) was grubbed in 1952 as many hills had been so weakened that cropping was greatly reduced.

WFF90 (from John Ford). *Plot 25.*

- (a) 1953: 22.96 cwt. 1954: 15.79 cwt.
 (b) 1953: "appearance very good, bright colour, aroma pleasant, not a Golding type" (Brewer).
 (c) 1953: (11.1.54) 6.15% alpha resin, 9.38% beta resins.
 (d) In 1947 the parent plant in Wye Field Nursery was recorded: "good crop, cone many-petalled, rich, ripe on Aug. 22nd"; in 1952 "growth fruitful, not biny, cropping to low down, cone solid, of good colour (light green)". Analysis (16.10.47) 8.28% alpha resin, 8.97% beta resins.

Plot 25: Hills planted 1951 and 1952. Bine fine and close-jointed, makes little head, but crops well right down the bine; attractive pale cones. Midseason or Early-Midseason.

- (e) In 1952 there was a severe attack of lateral and terminal spikes, so that no less than 996 spikes per 100 hills were produced. In 1953 and 1954 the number of spikes produced has been much less, working out at 90 and 39 per 100 hills. In 1954 there was a slight infection of the cones. There is no evidence of rootstock infection.

VARIETIES LISTED IN TABLE 3. FIRST GENERATION SEEDLINGS FROM OPEN POLLINATED FLOWERS OF BBI, WILD HOP, MANITOBA, CANADA.

Two named seedlings in this group, Brewer's Gold (C9a) and Bullion (Q43) are being successfully grown in this country as well as on a large scale in U.S.A. and Canada. In England there are at present 195 acres of Brewer's Gold and 158 acres of Bullion. Both varieties are in favour with certain firms of brewers. It is very desirable that brewing trials should be made with other seedlings

in this group, particularly as the parent plant BB1 is extinct. It is quite probable that the results of such trials would lead to the acceptance of some seedlings by a wider circle of brewers. On the cultural side the seedlings listed in Table 3, while equally vigorous and requiring only one bine to the string, are less susceptible to downy mildew disease than Brewer's Gold, particularly OQ22, OV80 and OX88; this might lead to a lowering of the cost of production.

Recent investigations at the Brewing Industry Research Foundation (7 and 8) have shown that the valuable constituent cohumulone is present in Brewer's Gold and Bullion in the proportion of 30%—40% of the alpha soft resin, while in the other varieties tested it is less than 10%. There are seven varieties listed in Table 3 of the same generation as Brewer's Gold and Bullion, and three varieties listed in Table 4 which have been raised from these two varieties; it is hoped that chemical investigations will be made to determine the proportion of cohumulone in all these.

OQ22. Plot 6.

This variety has been recorded in the trials at East Malling Research Station from 1932 to 1949 (Bibliography (1)). In general habit it is very similar to Bullion (Q43) and is late in season. The mean yield was 24·24 cwt. per acre, with a maximum yield of 31·59 cwt. in 1934 and minimum yield of 16·93 cwt. in 1949, a season of drought. The mean bushel/cwt. rate was 109; preservative values (P.V. = 10 alpha) ranged from 54 to 82. The variety had a favourable downy mildew record only about 5 per cent. of the hills producing spikes, but there was some evidence of rootstock infection. With the usual routine copper sprays the cones were never attacked.

Plot 6.

- (a) 1954: 22·42 cwt.
- (b) 1954: "aroma slightly unpleasant, not so evident on grinding, when aroma at first has resemblance to Golding; harsher background" (Brewer).
- (c) Hills were planted in 1953; in 1954 there was only a single spike in the 40-hill plot.

OW76. Plot 13.

This variety is very similar in most respects to OQ22 (above), but it is not quite such a good cropper. In the East Malling trials from 1936 to 1949 it gave usually over 20 cwt. to the acre (in 1941

24.34 cwt.; in 1943, 23.38 cwt.). Analyses in 1936 gave 7.78% alpha resin, 10.29% beta resins; 1943: 6.86% alpha resin, 10.09% beta resins; 1947: 7.40% alpha resin, 9.31% beta resins. There was no evidence of rootstock infection by downy mildew. It is a very vigorous and fruitful midseason variety.

Plot 13.

(a) 1954: 21.61 cwt.

(e) In the three-year period there was a mean of 14 spikes per 100 hills; there was a slight attack on the cones in 1954.

0021. Plot 58.

Very similar in general habit to OQ22 and OW76 (above), but the cones are rather smaller. Late. In the East Malling trials the mean yield for ten years was 21.33 cwt. per acre, with a mean bushel/cwt. ratio of 103. Analyses gave: 1938: 5.69% alpha resin, 12.50% beta resins; 1943: 7.50% alpha resin, 9.90% beta resins. OO21 is probably slightly more liable to spikes than either OQ22 or OW76.

Plot 58.

This is a very fruitful variety; field notes recorded in 1952 and 1954 "bumper" crop, cones smallish, rich in lupulin.

(e) Over the period 1951-54 there was an average of 13 spikes per 100 hills. There is no indication of rootstock infection. In 1953, the cones were moderately affected.

FF8. Plot 72.

A very vigorous variety, although bine tends to be backward and rather sparse early in season; cones develop well. The crop in the East Malling trials from 1936 to 1949 averaged 22.32 cwt. per acre, the lowest being 13.75 cwt. in 1949 and the highest 29 cwt. in 1943; average bushel/cwt. ratio 102. Analyses gave: 1936: (2.2.37) 5.35% alpha resin, 11.96% beta resins; 1937: (2.1.38) 5.31% alpha resin, 11.19% beta resins; 1938: (6.1.39) 5.88% alpha resin, 10.69% beta resins; 1943: (-11.43 to -12.43) 6.50% alpha resin, 6.32% beta resins. The production of spikes varied considerably from year to year; in the period 1936 to 1949 up to 80% of hills bore spikes in one season, but in five seasons there was complete freedom from spikes. FF8 is less resistant to the spike form of the disease than the other seedlings in this group.

Plot 72.

- (a) 1954: 25.48 cwt. per acre.
- (b) 1954: "a slightly rank aroma, no trace of American" (Brewer).
- (d) A very fruitful late variety (cropping to low down), of considerable promise; the cones are large, many-petalled, pointed.
- (e) Since 1951 spikes have been produced at the rate of from 3 to 15 per 100 hills, in 1951, 1952 and 1954, whilst in 1953 there were no spikes. There was a trace of infection on the cones in 1953; there has been no indication of rootstock infection.

OV80. Plot 66.

In the East Malling trials the 12 years' average yield was 19.67 cwt. per acre, with the highest yield 26.98 cwt. in 1939, and the lowest 11.11 cwt. in 1949, a year of severe drought. The mean bushel/cwt. ratio was 107. Midseason. Analyses gave: 1934: 7.00% alpha resin, 11.10% beta resins; 1935: 5.56% alpha resin, 12.34% beta resins; 1936: 6.33% alpha resin, 10.53% beta resins; 1937: 5.21% alpha resin, 12.78% beta resins; 1938: 6.56% alpha resin, 9.77% beta resins. The downy mildew record is quite satisfactory, with never more than 33% of hills bearing spikes, whilst in 7 out of 12 seasons there was an entire freedom from spikes. There was no evidence of rootstock infection. OV80 appears to be rather more liable to mould (powdery mildew) than others of this group.

Plot 66.

- (a) 1954: 25.39 cwt. per acre.
- (b) 1954: "aroma pleasant, but has a slightly rank background, resins good" (Brewer).
- (d) Planted in 1949 and 1951. In both 1952 and 1953 it was recorded as looking "very croppy". The measured crop in 1954 worked out at 25.39 cwt., one of the highest yields of the season. The bine is fruitful to low down, and the cones are amongst the best developed of all the seedlings of this parentage, being large, solid, and silky.
- (e) The record has been good, with complete freedom from spikes in 1953 and only 3 spikes per 100 hills in 1951, 1952 and 1954.

R1/38a. Plot 76.

In the East Malling trials, 1942-49, the yield averaged 18.36 cwt., with a bushel/cwt. ratio of 93; the variety being rather a poorer cropper than most of the same parentage. There are indications that it crops better at Wye (see below). It had quite a good downy mildew record; a maximum of 19% of hills had spikes in 1945, whilst in four seasons there were no spikes.

Plot 76.

- (a) 1952: 25.65 cwt., with bushel/cwt. ratio of 80. 1954: 19.67 cwt., with bushel/cwt. ratio of 109.
- (b) 1952: "appearance good, aroma 'American', pleasant; resin very good" (Brewer).
- (d) A heavy-cropping late variety inclined to be "biny", with many-petalled, dense, pointed cones, rich and greasy with lupulin.
- (e) Hills, planted in 1949, only produced spikes in 1952 (3 spikes per 100 hills), and in 1954 (21 spikes per 100 hills). There has been no evidence of rootstock infection. In 1953 there was a slight attack on the cones.

OX88. Plot 81.

The mean crop in the East Malling trials, 1935-49, was 19.11 cwt. per acre, with a maximum of 27.78 cwt. in 1939 and a minimum of 13.39 cwt. in 1949. Analyses gave: 1935: 5.20% alpha resin, 14.45% beta resins; 1936: 4.57% alpha resin, 12.60% beta resins; 1938: 4.96% alpha resin, 10.03% beta resins; 1941: (26.2.42) 2.47% alpha resin, 10.64% beta resins. As regards downy mildew, from 1935-49 there was a maximum of 56% of hills with spikes in one season, whilst in six seasons there was complete freedom from spikes.

Plot 81.

- (d) A heavy-yielding late variety, with bold, many-petalled cones—a "picker's hop". The cones are well developed, even in unfavourable seasons as in 1954.
- (e) There has been no spike production except in 1953, when it was only at the rate of 4 spikes per 100 hills. There was a slight infection on the cones in 1953. Although the spike position is quite satisfactory, there is some evidence that hills may be weakened, and in a few cases killed, by downy mildew infection.

VARIETIES LISTED IN TABLE 4. SECOND GENERATION FROM BB1, WILD HOP, MANITOBA, CANADA. THIS GENERATION WAS DERIVED BY OPEN POLLINATION AT WYE OF FIRST GENERATION SEEDLINGS.

WFG66 (from Bullion (Q43)). *Plot 7.*

The parent plant in Wye Field Nursery was recorded in 1947: "good crop, with bold, solid cones of a 'rubber-like' consistency, very rich". Analysis: (17.10.47) 8.29% alpha resin, 13.33% beta resins.

Plot 7.

- (a) 1953: 24.61 cwt. per acre. 1954: 20.71 cwt., with a bushel/cwt. ratio of 85.
- (b) 1953: "appearance very good, aroma pleasant, rich side. The aroma is English, with a resemblance to Fuggles" (Brewer). 1954: "aroma pleasant, with rough background; resins good" (Brewer).
- (c) 1953: 6.00% alpha resin, 16.08% beta resins.
- (d) The Wye Field spacing and height of wirework are too cramped for this variety, so that all the crop is on the "heads", with barren lower laterals. Late.
- (e) Spikes have been produced at the rate of 12, 25 and 8 per 100 hills in 1952-54. There was a trace of infection on the cones in 1954. There is no evidence of rootstock infection.

There are indications that WFG66 may prove to be a valuable New Variety.

WFH65 (from Bullion (Q43)). *Plot 61.*

- (a) 1952: 25.39 cwt. 1953: 26.54 cwt. 1954: 25.12 cwt.
- (b) 1954: "appearance good; fresh, slightly fruity aroma, trace of American background; resins poor" (Brewer).
- (c) Parent plant in Wye Field Nursery, 1947: 7.54% alpha resin, 12.38% beta resins.
- (d) Planted 1949-50. Moderate vigour, very croppy with little head, but long "ropes" of hops; cones pale, firm, rich in lupulin. A heavy-cropping variety. Midseason-Late.
- (e) Spike production has varied from 13 per 100 hills in 1954 to 28 per 100 hills in 1953. There was a slight attack on the cones in 1954. There is no evidence of rootstock infection.

OH77 (from R3/100, seedling of BB1). Plot 21.

In the East Malling trials the yield for eight years averaged 22.22 cwt. per acre, with a bushel/cwt. ratio of 96. Analyses: the mean of five seasons' analyses (1943-48) gave 6.64% alpha resin and 10.59% beta resins. 1945: "aroma unusual, though not unpleasant" (Brewer). 1946: "appearance good, aroma slightly unusual, though not unpleasant, confirming last year's observation" (Brewer). 1948: "aroma pleasant, rather aromatic and lacking in true hop aroma, good resin" (Brewer). Vigorous growth; at East Malling this variety was successfully grown with 2 bines per string (Butcher-work, 7 ft. $\times$ 7 ft.), but at Wye on upright umbrella work, 6 ft. square, it is too "housed-in" even with only 1 bine to the string. At East Malling it was remarkably free from the spike form of downy mildew. In the period 1941-49 spikes were only found in two seasons, and even then only between 6% and 7% of the hills were affected. However, at Wye in 1954, there was, for the season, a fairly high incidence of spikes, the figure being 184 spikes per 100 hills. There was a trace of cone infection in 1953 and 1954. There has been no evidence of rootstock infection. It is late in season.

Plot 21.

- (a) 1952: 23.82 cwt., bushel/cwt. ratio 98. 1954: the crop was estimated as "good, cones well developed".
- (e) See above.

OD18 (from R3/100, seedling of BB1). Plot 63.

The average yield over 8 years at East Malling was 15.13 cwt., with a bushel/cwt. ratio of 110. Downy mildew spikes were not unduly numerous and in several seasons there were none. The behaviour at Wye was different (see below).

Plot 63.

- (a) 1952: 26.83 cwt. 1953: 22.51 cwt.
- (b) 1935: (parent plant) "mild Oregon flavour, not unpleasant" (Merchant). 1952: "appearance good, green; good fresh, fragrant hop aroma, faint suggestion of American, fair resin" (Brewer). 1953: "aroma pleasant, not distinctive, resin moderate" (Brewer).
- (c) 1935: (parent plant) (22.11.35) 6.54% alpha resin, 14.89% beta resins. 1952: (22.12.52) 3.70% alpha resin, 12.96% beta resins. 1953: (11.1.54) 4.17% alpha resin, 13.73% beta resins.

- (d) This variety is midseason; it appears much to prefer the Wye brick earth to the East Malling light loam overlying porous rock (ragstone).
- (e) During the past three seasons (plot planted in 1949 and 1951) spikes have been produced at the rate of 115, 378 and 478 per 100 hills. In 1953 there was a slight attack on the cones and in 1954 the attack was bad. No evidence of rootstock infection.

OR38 (from R3/100, seedling of BB1). Plot 64.

The parent plant in Wye Nursery was recorded in 1938: "Sept. 7th, not quite ripe, good crop, large bold cone, 'primrose' colour, rich". Analysis: 1938: (14.2.39) 3.73% alpha resin, 13.31% beta resins.

Plot 64.

- (a) 1952: 21.05 cwt. 1953: 23.94 cwt.
- (b) "Appearance good, aroma rather coarse, resin moderate" (Brewer). 1953: "appearance attractive, aroma coarse, do not care for it, resin good" (Brewer).
- (c) 1952: (22.12.52) 3.22% alpha resin, 10.18% beta resins. 1953: (4.1.54) 4.49% alpha resin, 10.57% beta resins.
- (d) Midseason; this is another variety (see above) which seems to do better at Wye than at East Malling where the mean yield for 1945-49 was only 15.58 cwt.
- (e) Both at East Malling and at Wye this variety has been very free from spikes; at East Malling from 1945-49 there were spikes in only one season; and at Wye for 1951-54, one season (1953) was completely "clean", whilst in the other three the number of spikes per 100 hills never exceeded 8. There has been no evidence of rootstock infection and the cones have not been attacked.

OT9 (from Brewer's Gold (C9a)). Plot 67.

In the East Malling trials the mean yield for 1946-49 was 15.09 cwt., with bushel/cwt. ratio of 92.

Plot 67.

- (a) 1952: 22.42 cwt. 1953: 25.93 cwt. 1954: 22.15 cwt.

- (b) 1938: "good appearance, poor weak aroma, not pleasant" (Merchant). 1952: "appearance good, aroma pleasant, normal hop type, resin fair to good" (Brewer). 1953: "appearance good, aroma pleasant, coarse type, very good resins" (Brewer). 1954: "appearance good; aroma slight rankness, with very faint American, not unpleasant" (Brewer).
- (c) Parent plant in Nursery, 1937: (27.4.38) 7.08% alpha resin, 12.98% beta resins. 1938: (2.12.38) 8.77% alpha resin, 9.38% beta resins. Plot 67, 1952: (22.12.52) 5.52% alpha resin, 8.67% beta resins. 1953: (4.1.54) 6.20% alpha resin, 9.24% beta resins.
- (d) A heavy cropping variety with bold, many-petalled dense cones, very rich in lupulin. In some seasons it has exceeded Brewer's Gold (C9a) in richness. Midseason-Late. Another variety which prefers Wye brick earth to East Malling loam.
- (e) Little subject to basal spikes, with around 9 spikes to 100 hills at Wye. There is some evidence of rootstock infection. There was a slight attack on the cones in 1953. At East Malling there was considerable late lateral infection in some seasons.

VARIETIES LISTED IN TABLE 5. THIRD GENERATION FROM BBI, WILD HOP, MANITOBA, CANADA. THIS GENERATION WAS DERIVED BY OPEN POLLINATION AT WYE OF SECOND GENERATION SEEDLINGS.

WFH16 (from *WFC79*, seedling of *Bullion* (Q43)). Plot 34.

- (a) 1947: 21.50 cwt. 1950: 26.74 cwt. 1951: 12.42 cwt. 1952: 15.94 cwt. 1953: 19.72 cwt. 1954: 11.34 cwt. The bushel/cwt. ratio was 80 in 1950 and 95 in 1952.
- (b) 1947: "good side, silky, peculiar aroma" (Merchant). 1948: "aroma pleasant, fragrant, high resin" (Brewer). 1950: (19.2.51) "appearance very good, nice colour, aroma mild, very pleasant. I have re-examined the sample today (18.4.51), I find a coarseness of aroma which may have developed since the hop was first examined; quite definitely it lacks the delicacy of *Golding*, I cannot find any trace of American aroma" (Brewer). 1951: "appearance very good, nice colour, aroma pleasant, not strong, no character"

(Brewer). 1953: "aroma pleasant, but not distinctive, and not strong; resins good" (Brewer).

- (c) Parent plant, 1941: 5.38% alpha resin, 10.43% beta resins; and 1948: (21.12.48) 6.88% alpha resin, 10.24% beta resins. *Plot 34*: 1950: (9.2.51) 5.37% alpha resin, 9.67% beta resins; 1951: (30.1.52) 4.69% alpha resin, 8.42% beta resins; 1953: 7.14% alpha resin, 9.76% beta resins.
- (d) A very early variety, with bine of limited growth and though fruitful, scarcely or not making a "head"; crop very variable according to season; the cones are small, many-petalled, silky and rich in lupulin. In 1940 the cones were ripe on August 18th, and in 1952 on August 19th; in 1950 the crop was picked on August 24th. In most seasons it is ripe before the end of August, but in 1954 it was hardly ripe by September 2nd.
- (e) In the period 1950-54, spikes occurred only in 1953, when they were at the rate of 35 per 100 hills, and consisted only of lateral infections in June and July. There has been no evidence of rootstock infection. A very satisfactory variety from the downy mildew angle.

WFH16 is subject to a disease to which the name of "wither cone" has been given. Each season, just before ripening, a variable proportion of the cones, situated along the laterals, change colour, wither and die. The number of cones affected is not sufficient to affect appreciably the crop. The cause of the disease is unknown.

It remains to be seen whether, by close planting, for which its habit is suitable, this variety is fruitful enough over a period of years to warrant commercial planting. A very early variety would be welcomed for machine picking.

A trial plot of WFH16 has been started on a farm in Worcester-shire.

WFJ53 (from WFC79, seedling of Bullion (Q43)). *Plot 44*.

- (a) 1951: 24.85 cwt. 1952: 25.65 cwt. The bushel/cwt. ratio in 1951 was 92 and 96 in 1952.
- (b) 1948: "most attractive looking sample, the flavour seems to approximate to Bullion Hop, but not quite so sharp" (Merchant); 1948: "appearance very good, good colour, strong American aroma" (Brewer). 1949: "very good

appearance, aroma pleasant" (Brewer). 1951: "mild American aroma" (Merchant).

- (c) 1948: (21.12.48) 6.52% alpha resin, 8.42% beta resins.
1949: (20.2.50) 8.67% alpha resin, 10.23% beta resins.
1951: (5.12.51) 4.87% alpha resin, 8.47% beta resins.
- (d) The vigorous and rather stiff bines make this variety a very bad climber; considerable extra attention is needed to keep the bines to the strings during June. The bines often crop to the ground; the cones are large, long and dense, and rich in lupulin. Several of the clone-plants in the nursery have had "bumper" crops in various seasons. Late.
- (e) For the period 1950-54 the mean spike production has been at the rate of 201 spikes per 100 hills, with a maximum of 435 in 1952 and a minimum of 20 in 1950. There is some evidence of rootstock infection; in two seasons there has been a moderate infection of the cones.

WFB117 (from III49, seedling of Brewer's Gold (C9a)). *Plot 39.*

- (a) 1947: 22.25 cwt. 1951: 27.01 cwt. 1952: 19.45 cwt.
1953: 20.80 cwt. 1954: 17.02 cwt.
- (b) 1946: "cones firm, very nice; aroma pleasant, robust; lupulin good" (Brewer). 1947: "good side, nice flavour" (Merchant); 1947: "cones good, aroma 'black-currant', lupulin good" (Brewer). 1951: "appearance very good, aroma pleasant, slight trace of American smell, resins moderate" (Brewer).
- (c) 1946: (2.12.46) 6.57% alpha resin, 11.69% beta resins.
1947: (23.3.48) 4.22% alpha resin, 9.71% beta resins.
1951: (30.1.52) 4.73% alpha resin, 11.01% beta resins.
- (d) Produces ample bine for training; nice pale cones. Mid-season-Late.
- (e) The mean number of spikes per 100 hills for the period 1950-54 was 19. There is no evidence of rootstock infection and the cones have been free from disease.

In the brewing trials carried out in 1947 by Messrs. Fletcher and McLintock (6), the physical examination of *WFB117* was recorded as "appearance badly affected by weather, but nevertheless promising. Good strong, robust, pleasant, aroma. Lupulin good. Firm, shapely cones." The results were satisfactory in the copper

hop test, and the hop was found to blend well; in the dry hop tests it gave a most pleasant flavour and good bitter, not excessive.

WFD82 (from *II149*, seedling of *Brewer's Gold* (C9a)). *Plot 41*.

- (a) 1950: 27.01 cwt. 1951: 21.32 cwt. 1952: 20.26 cwt. 1954: 20.53 cwt.
- (b) 1947: "aroma 'black-currant', lupulin good" (Brewer); "strong American flavour" (Merchant). 1950: "nice American flavour" (Merchant); "appearance very good, cones smaller than average, aroma with a pleasant American tang" (Brewer).
- (c) 1947: (23.3.48) 4.06% alpha resin, 10.58% beta resins. 1950: (12.2.51) 5.44% alpha resin, 12.52% beta resins.
- (d) Plentiful bine for training. The cones somewhat resemble those of a *Golding* in being small, but have more "petals", are denser and weigh heavier; in 1952 only 90 bushels were required to the cwt. of dried hops. Midseason.
- (e) The mean number of spikes per 100 hills for the period 1950-54 was 113. In the last two seasons the rate has been over 180 spikes. There is no evidence of rootstock infection and there has been no attack on the cones.

WFD88 (from *Nonsuch* (OB53), seedling of *334a*). *Plot 32*.

The parent plant in *Wye Field Nursery* was recorded in 1938: "Vigorous and fruitful, cones large, firm, produced rather singly, rich, aroma pleasant." Midseason-Late. Analysis: 1938: 7.66% alpha resin, 12.24% beta resins.

Plot 32.

- (a) 1951: 28.26 cwt.; bushel/cwt. ratio 97. 1952: 18.10 cwt. with ratio 101.
- (b) 1938: "good appearance, but dull, good soft rub, mild American aroma. We should have liked *WFD88* if the appearance had not been so dull" (Merchant). 1948: "pleasant delicate flavour, resembling a *Golding*, which is also evident in the appearance, very good side, slightly dull complexion" (Merchant); 1948: "appearance very good, primrose; aroma fragrant, leading to perfume, good resin" (Brewer). 1949: "aroma pleasant" (Brewer). 1951: "mild Oregon aroma, good for American substitute" (Merchant).

- (c) 1948: 6.79% alpha resin, 10.95% beta resins. 1949: (16.2.50) 7.67% alpha resin, 10.55% beta resins. 1951: 4.91% alpha resin, 10.54% beta resins.
- (d) Bine crops well down, but cones are carried rather singly. It appears to be midseason.
- (e) Mean number of spikes per 100 hills for 1950-54 was 87, with 11 in 1950 and 228 in 1952. There is no evidence of rootstock infection. In 1950 there was a moderate, and in 1953 a slight, attack on the cones.

VARIETIES LISTED IN TABLE 6. THIRD GENERATION FROM THE AMERICAN VARIETY OREGON CLUSTER. THIS GENERATION WAS RAISED BY OPEN POLLINATION AT WYE OF OP13, A SEEDLING PRODUCED BY CROSSING AN ENGLISH MALE WITH M45, A SEEDLING PRODUCED BY CROSSING AN ENGLISH MALE WITH OREGON CLUSTER.

CC77. Plot 71.

The crop at East Malling from 1936 to 1946 averaged 15.76 cwt. per acre, the lowest being 11 cwt. in 1951 and the highest 20.84 cwt. in 1939. Analyses; 1936: (29.1.37) 6.80% alpha resin, 10.01% beta resins; 1937: (11.3.38) 5.56% alpha resin, 11.64% beta resins; 1938: (23.1.39) 5.45% alpha resin, 9.26% beta resins; 1941: (12.1.42) 6.34% alpha resin, 11.00% beta resins; 1942: (25.1.43) 6.08% alpha resin, 9.59% beta resins.

Plot 71.

- (a) 1953: 31.63 cwt. 1954: 22.38 cwt.
- (b) 1953: "fresh fragrant aroma, with coarse background, high resin content; the aroma is 'new', i.e. neither American nor English" (Brewer). 1954: "good, bright colour; aroma pleasant, good hop aroma, but not Golding type; rich resins" (Brewer).
- (c) 1953: (21.12.53) 8.03% alpha resin, 6.12% beta resins.
- (d) Appears to prefer the moister Wye brick earth to the drier Malling loam. Late in season. The cones are solid, of good colour and silky texture. There are indications that CC77 is a good "keeper" in storage.

- (e) Both at East Malling and Wye has been remarkably free from spikes; in the period 1936-49 at East Malling in no less than nine seasons there were no spikes. At Wye, since 1950, there have been 2 spikes only in the 42-hill plot in one season (1952). There has been no indication of rootstock infection nor have the cones been attacked. In 1945 there was a generally very severe attack of mould (powdery mildew) at East Malling and CC77 remained free from the disease.

Since the records at East Malling and at Wye show that CC77 is definitely resistant to downy mildew, field plots on farms will be established to test this character further.

L11. Plot 48.

The mean yield, 1942-48, of Row D26 at East Malling was 13·80 cwt. per acre, and the mean yield of Row E12, 1936-40 was 20·50 cwt. per acre. There is some evidence that hills may have been weakened by downy mildew attack, but not killed, and this may partly account for the low yields in 1942-48. The yields for the period 1936-40 are somewhat increased as they are based on a row planted 7 ft. × 6 ft., instead of the usual 7 ft. × 7 ft. Analyses: 1936: (1.12.36) 6·12% alpha resin, 11·89% beta resins; 1937: (18.1.38) 5·97% alpha resin, 10·15% beta resins; 1938: (24.11.38) 4·70% alpha resin, 10·56% beta resins.

Plot 48.

- (a) 1954: 21·33 cwt.
 (b) 1954: "aroma very pleasant, perhaps very faint American; resins poor" (Brewer).
 (d) The many-petalled, particularly dense, imbricated cones do not shatter and make L11 very suitable for machine-picking. Late in season.
 (e) The behaviour was rather erratic; the hills were usually very free from basal spikes, but in some seasons there was a high incidence of lateral and terminal spikes later in the season, e.g. in 1953 spikes (mainly lateral and terminal) were at the rate of 251 per 100 hills, whereas in 1954 there were only 5 basal spikes per 100 hills. In 1954 there was a slight attack on the cones.

VARIETY LISTED IN TABLE 7. FOURTH GENERATION
FROM THE AMERICAN VARIETY OREGON CLUSTER.
A SEEDLING RAISED BY OPEN POLLINATION AT
WYE OF L11 REFERRED TO ABOVE.

ADD50. Plot 62.

The parent plant in Wye Field Nursery was recorded in 1949: "good crop, picked Sept. 5th, bold, many-petalled cones, firm, pointed, all the cones finishing well, with no 'underhops', pale cool green colour, rich, aroma pleasant". Several clone-plants were recorded subsequently as having "bumper" crops.

The mean yield, 1943-49, in the East Malling Trials was 15.35 cwt. per acre.

Plot 62.

- (a) 1952: 24.33 cwt. 1953: 24.04 cwt.
- (b) 1952: "appearance very good, pale colour, aroma pleasant, fresh fragrance (esters), resin good; a promising variety" (Brewer). 1953: "appearance good, aroma pleasant, query Golding, resin fair" (Brewer).
- (c) Parent plant, 1938: (21.12.38) 4.85% alpha resin, 11.15% beta resins; parent plant, 1949: (2.11.49) 7.22% alpha resin, 12.70% beta resins. *Plot 62*, 1952: (22.12.52) 5.40% alpha resin, 10.41% beta resins; 1953: (11.1.54) 5.16% alpha resin, 10.25% beta resins.
- (d) One of the most promising of the newer varieties, with its well-developed cones of good colour. It appears not to have liked the Malling loam, and to have responded to the Wye brick earth. Late.
- (e) Basal spikes not usually numerous, but lateral and terminal spikes very plentiful in some years. In the last three seasons spikes per 100 hills have varied from 265 to 450. In 1953 and 1954 there was a slight infection of the cones. There has been no indication of rootstock infection.

VARIETY LISTED IN TABLE 8. SECOND GENERATION
FROM *HUMULUS AMERICANUS* VAR. *NEOMEXI-*
CANUS. A SEEDLING RAISED BY OPEN POLLINATION
AT WYE OF Y90, A SEEDLING OF *NEOMEXICANUS*.

R4/40a. Plot 77A.

The crop in the East Malling trials from 1939-49 averaged 19.23 cwt. per acre. Analyses: 1938: (29.3.39) 4.52% alpha resin, 8.43%

beta resins; 1941: (3.3.42) 5.05% alpha resin, 8.85% beta resins; 1943: (3.3.44) 6.52% alpha resin, 8.85% beta resins.

Plot 77A.

- (a) 1953: 23.77 cwt.
- (b) 1953: "aroma strong, 'black-currant', resin fair" (Brewer).
- (c) 1953: (4.1.54) 6.03% alpha resin, 7.85% beta resins.
- (d) A heavy-cropping midseason-late variety, the fertile laterals sometimes reaching to the ground; the many-petalled cones are remarkably clustered. There are indications that it is a good "keeper" in storage.
- (e) At East Malling, 1938-49, in six seasons there were no spikes. At Wye, 1950-54, the mean number of spikes per 100 hills was 11. There was a trace of infection on the cones in 1953. There is no evidence of rootstock infection.

VARIETIES LISTED IN TABLE 9. THIRD GENERATION FROM *HUMULUS AMERICANUS* VAR. *NEOMEXICANUS*. SEEDLINGS RAISED BY OPEN POLLINATION AT WYE OF PROGENY OF Y90, A SEEDLING OF *NEOMEXICANUS*.

AOR43 (from R1/94, seedling of Y90).

- (a) 1953: 25.12 cwt. 1954: 14.04 cwt.
- (b) 1953: "appearance good, aroma strong, American, resin good" (Brewer).
- (c) Parent plant, 1938: (6.12.38) 8.04% alpha resin, 10.33% beta resins; 1953: (4.1.54) 7.81% alpha resin, 9.89% beta resins.
- (d) An "American" hop, with good yield, cropping to low down, with many-petalled dense cones rich in lupulin. Its habit suggests it might prove to be very suitable for machine-picking. Late.
- (e) Only a moderate number of spikes have been produced, the mean (1950-54) being 26 spikes per 100 hills. There is no evidence of rootstock infection and cones have not been attacked.

AOS14 (from R1/94, seedling of Y90). *Plot 84.*

The mean yield in the East Malling trials (1942-48) was 15.48 cwt. per acre, with a bushel/cwt. ratio of 98. Analyses: parent

plant, 1935: (14.11.35) 3.05% alpha resin, 12.98% beta resins; 1936: (15.10.36) 5.59% alpha resin, 14.17% beta resins.

Plot 84.

- (a) 1954: 22.71 cwt.
- (b) Parent plant, 1936: "appearance very good, big hop; soft, thick rub; pleasant 'Manitoba' flavour. I like this hop" (Merchant).
- (d) Early-midseason, cropping well down the bine, with long narrow compact cones in dense "heads".
- (e) Rather prone to spikes, the mean for the last three seasons being 128 spikes per 100 hills. No evidence of rootstock infection; no attack on the cones.

OL53 (from EE92, seedling of Y90). Plot 75.

The average yield in the East Malling trials, 1940-49, was 22.22 cwt. per acre. Analyses: 1934: (28.1.35) 5.99% alpha resin, 9.45% beta resins; 1946: (16.12.46) 5.19% alpha resin, 6.35% beta resins.

Plot 75.

- (a) 1952: 23.50 cwt. 1953: 28.36 cwt. 1954: 23.77 cwt.
- (b) East Malling. 1934: "very attractive appearance, good rub, strong, 'Manitoba' aroma suggestive of pear-drops" (Merchant). 1946: "good, but faded appearance, good side, nice soft hop, weak aroma, not pleasant" (Merchant). 1947: "appearance very good, bright; nice cones, aroma is pleasant with slight perfume; lupulin fair" (Brewer). Wye. 1952: "appearance very good, attractive pale colour, aroma pleasant, good resin content" (Brewer). 1953: "nice pale yellow-green colour, aroma aromatic, resin fair" (Brewer). 1954: "appearance very good, good colour, large cones; aroma pleasant, slightly rough, lacking in fragrance this year, non-American; moderate resin" (Brewer).
- (c) 1952: (22.12.52) 4.22% alpha resin, 7.39% beta resins. 1953: (4.1.54) 4.85% alpha resin, 7.79% beta resins.
- (d) A very fruitful midseason variety; the cones are large, many-petalled and of a primrose colour throughout; the aroma is strongly suggestive of pear-drops (amyl-acetate).

This variety would appeal to those brewers who put a high value on colour.

- (e) Very liable to both spikes and cone infection. In the past three seasons the number of spikes per 100 hills has varied from 213 (1953) to 340 (1954). At East Malling there were slight attacks on the cones in 1943, 1944 and 1945, and at Wye a moderate attack in 1953. There has been no evidence of rootstock infection.

ACKNOWLEDGMENT

We are greatly indebted to Mr. L. Fletcher, of Messrs. Wm. Younger and Co. Ltd., Edinburgh, for his kindness in evaluating, over many years, numerous samples of New Seedling Varieties of Hops and supplying many chemical analyses.

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APPENDIX II

THE CHALLENGE CUPS FOR NEW VARIETIES OF HOPS

PROFESSOR E. S. SALMON

This competition is divided into three classes: (1) the Brewers' Cup, for hops intended as substitutes for American hops; this Challenge Cup was offered in 1944 by Messrs. Barclay, Perkins, Messrs. Guinness and Messrs. Whitbread; (2) the Growers' Cup, for hops intended to augment English commercial varieties; this cup was offered in 1946 by the Association of Growers of the New Varieties of Hops; (3) the Hop Merchants' Association's Cup, offered in 1949 by this Association for New Varieties certified as showing tolerance to *Verticillium* wilt.

The eleventh competition was held, under the auspices of the Institute of Brewing, in the showrooms of Messrs. Wigan, Richardson & Co., 15 Southwark Street, London, on November 23rd and 24th, 1954, the judges being Mr. Dudley Le May, Mr. A. E. Quin, and Lieut.-Col. F. N. Richardson, T.D. A "List of Entries" is given below in Tables 1-3, together with the analyses carried out at Wye College, in November, 1954, by Mr. E. W. Weston, B.Sc.

The Exhibition was taken by Messrs. Wigan, Richardson & Co. to Worcester, on December 2nd, 1954, at the request of the West Midland Province of the National Agricultural Advisory Service.

The Brewers' Cup (Table 1) was awarded to Mr. J. Nott, for a sample of Bullion (Q43), with an analysis of 8.42 per cent. alpha resin and 11.80 per cent. beta resins; this was an outstanding growth, with bold cones, in a difficult season. The second place was given to the same variety, grown by Mr. Wm. Alexander; this sample gave 8.23 per cent. alpha resin and 9.82 per cent. beta resins.

The Growers' Cup (Table 2) was awarded to Mr. J. Turner for a sample of Northern Brewer (WFB135) with the excellent analysis of 9.15 per cent. alpha resin and 10.68 per cent. beta resins. It is noteworthy that no less than fourteen growers sent in samples of this variety; the analyses of these ranged from 6.67 per cent. to

9.70 per cent. alpha resin and averaged 8.52 per cent. The preservative value of Northern Brewer was far above that of the Golding and "Golding Varieties" for the season; brewers have now the choice of fourteen growths from twelve parishes in Kent, Sussex, Worcestershire and Herefordshire. The acreage of Northern Brewer as given by the Hops Marketing Board, has increased from 48 acres in 1953 to 87 acres in 1954, and further planting up is actively in progress.

TABLE 1
ENTRIES FOR BREWERS' CHALLENGE CUP, 1954

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Brewer's Gold (C9a)</i>			
E. M. Gorst	Brenchley, Kent	8.65	11.01
W. Alexander, Ltd.	Eynsford, Kent	8.05	10.81
A. & K. J. Amos	Wye, Kent	8.04	10.01
Wm. Skinner & Son. . . .	East Sutton, Kent	7.68	9.62
E. E. Taylor	Kingsdown, Kent	7.65	9.08
E. L. Worsfold	East Sutton, Kent	7.53	9.73
A. Guinness, Son & Co., Ltd.	Sittingbourne, Kent	6.54	9.39
R. D. Wickham	Brenchley, Kent	6.02	13.14
<i>Bullion Hop (Q43)</i>			
*J. Nott	Tenbury, Worcs.	8.42	11.80
†W. Alexander, Ltd.	Shoreham, Kent	8.23	9.82
Furnace Farms, Ltd. . . .	Lamberhurst, Kent	7.96	11.73
E. M. Gorst	Brenchley, Kent	7.72	10.83
T. E. Wimshurst	Brenchley, Kent	7.39	11.26
W. Alexander, Ltd.	Shoreham, Kent	7.19	11.18
B. P. Tompsett	Yalding, Kent	7.14	9.55
A. Guinness, Son & Co., Ltd.	Robertsbridge, Sussex	6.56	10.98
J. A. Worley	Chart Sutton, Kent	6.47	10.02
A. Guinness, Son & Co., Ltd.	Sittingbourne, Kent	5.57	9.80
<i>Malling Midseason (BB28)</i>			
B. P. Tompsett	Yalding, Kent	6.17	12.10
<i>Pride of Kent (170a)</i>			
J. F. Bomford, Ltd. . . .	Fladbury, Worcs.	6.10	12.07
<i>D1 (E.M.R.S.)</i>			
Brian H. Day	Marden, Kent	4.78	7.34
<i>C2 (E.M.R.S.)</i>			
Brian H. Day	Marden, Kent	2.92	9.65

* Awarded Cup.

† Placed second.

TABLE 2
ENTRIES FOR GROWERS' CHALLENGE CUP, 1954

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Northern Brewer</i> (WFB135)			
B. P. Tompsett	Yalding, Kent	9.70	11.06
*J. Turner	Bosbury, Hereford	9.15	10.68
J. Nott	Tenbury, Worcs.	8.91	9.39
J. F. Bomford, Ltd. ..	Fladbury, Worcs.	8.62	8.89
G. Nott	Eardiston, Worcs.	8.41	8.73
J. & R. Day	Hunton, Kent	8.06	9.16
W. D. Hukins	Tenterden, Kent	7.37	9.64
A. & K. J. Amos	Wye, Kent	7.36	9.62
H. Veall	Capel, Kent	7.33	9.34
J. A. Worley	Chart Sutton, Kent	7.13	9.10
E. L. Worsfold	East Sutton, Kent	6.91	8.66
Wm. Skinner & Son.. ..	East Sutton, Kent	6.84	8.97
D. Mackelden	Chart Sutton, Kent	6.82	9.11
A. Guinness, Son & Co., Ltd.	Sittingbourne, Kent	6.67	8.94
<i>John Ford Hop</i> (WFA90)			
J. Nott	Tenbury, Worcs.	9.61	10.37
T. E. Wimshurst	Brenchley, Kent	7.98	9.17
<i>Pride of Kent</i> (170a)			
B. P. Tompsett	Yalding, Kent	7.41	12.91
A. & K. J. Amos	Wye, Kent	6.56	12.04
H. Veall	Capel, Kent	6.39	13.48
<i>OF27</i>			
†J. Nott	Tenbury, Worcs.	7.18	9.95
<i>Early Promise</i> (X35)			
B. P. Tompsett	Yalding, Kent	6.32	7.65
Wm. Skinner & Son.. ..	East Sutton, Kent	5.90	7.10
<i>Norton Court Golding</i> (WFG19)			
B. P. Tompsett	Yalding, Kent	5.90	10.56
J. Nott	Tenbury, Worcs.	5.14	8.69
<i>"1147"</i>			
Whitbread & Co., Ltd. ..	Yalding, Kent	5.84	7.50
<i>AGG8</i>			
A. Guinness, Son & Co., Ltd.	Sittingbourne, Kent	5.48	8.36
<i>Bramling Cross</i> (OT48)			
Brian H. Day	Marden, Kent	5.04	7.92
<i>Early Choice</i> (FF21)			
J. F. Bomford, Ltd. ..	Fladbury, Worcs.	4.29	6.53

* Awarded Cup.

† Placed second.

The second place was given to a sample, grown by Mr. J. Nott, of the variety "OF27"; this had the excellent analysis of 7.18 per cent. alpha resin and 9.95 per cent. beta resins. OF27 is a seedling raised at Wye College in 1910, from "open" flowers of the German variety "Hersbruck". This variety has proved in trials made at Wye College to be so susceptible to mosaic disease that it has not been recommended for commercial cultivation. Mr. Nott has reported that with him, at Tenbury, Worcestershire, it has not proved to be more susceptible to mosaic disease than the Mathon.

As in previous years, the samples shown of Pride of Kent (170a) are distinguished by unusually high percentages of beta resins; the chemistry of these resins is now being investigated*, and it would be interesting to know what particular constituents are present in Pride of Kent.

The sample of Early Promise (X35) grown by Mr. B. P. Tompsett, gave 6.32 per cent. alpha resin and 7.65 per cent. beta resins. As noted in the annual report of this Department for 1953, p. 47, this variety, which is early in some districts, proves on analysis to have good preservative value; it is decidedly resistant to downy mildew and also to mould.

Another variety, not exhibited before, is "AGG8", grown by Messrs. A. Guinness, Son & Co. Ltd. This seedling with 5.48 per cent. alpha resin and 8.36 per cent. beta resins was raised at Wye College in 1931 from "open" flowers of Brewer's Gold (C9a). In 1934 a box sample was submitted to Mr. C. G. Tosswill, of Messrs. Wigan, Richardson & Co., who reported: "Nice buttony hop, with good soft rub and pleasant flavour. I liked AGG8 distinctly; it has a trace of 'Manitoba' flavour, but this might be described as sweet, and I think would appeal to Brewers." This prediction has been fulfilled to the extent that a brewer-grower has planted up 1 acre. The 1934 sample analysed 6.97 per cent. alpha resin and 10.40 per cent. beta resins; AGG8 is a very vigorous variety and a good cropper, requiring only one bine to the string; it is remarkable for the way the cones "hang" and never "go off". It is about the same season as Brewer's Gold and the cones, which are easy to pick, develop well in both wet and dry seasons; it is not unduly susceptible to downy mildew and mould has not occurred. It is one of the easiest varieties to grow.

The cup for varieties tolerant to *Verticillium* wilt (Table 3) was awarded to Messrs. Whitbread & Co. Ltd., for their sample of 1147, with the good analysis of 6.10 per cent. alpha resin and

* G. A. Howard, in *Journ. Inst. Brewing*, LX, 410 (1954).

9.67 per cent. beta resins. "Bramling Cross" (OT48) was placed second. There was a record entry for this class; the number may be expected to increase as the acreage in bearing of both varieties mentioned above is steadily increasing.

TABLE 3

ENTRIES FOR HOP MERCHANTS' ASSOCIATION'S CHALLENGE CUP, 1954

Variety and Grower	Parish	Hops moisture-free	
		alpha acid %	beta fraction %
<i>Keyworth's Midseason</i> (OR55)			
T. R. Boorman	Lamberhurst, Kent	6.64	8.89
Furnace Farms, Ltd. ..	Lamberhurst, Kent	6.32	7.74
E. M. Gorst	Brenchley, Kent	6.24	6.68
Brian H. Day	Marden, Kent	6.00	8.57
H. E. Hall & Son	Brenchley, Kent	5.96	7.63
G. Britcher	Marden, Kent	5.86	8.61
"1147"			
*Whitbread & Co., Ltd. ..	Yalding, Kent	6.10	9.67
<i>Bramling Cross</i> (OT48)			
†Brian H. Day	Marden, Kent	5.33	6.84
<i>D1</i> (E.M.R.S.)			
Brian H. Day	Marden, Kent	4.82	7.12
<i>C2</i> (E.M.R.S.)			
G. Britcher	Marden, Kent	4.16	9.95
Brian H. Day	Marden, Kent	3.28	8.04

* Awarded Cup.

† Placed second.

APPENDIX III

PUBLICATIONS

E. S. SALMON: "Copper Hop: A New Variety." Leaflet, Wye College, Kent. April, 1954. Price 2s.

The subject of this leaflet is the seedling, ref. no. OK40, to which the name Copper Hop has been given. It is of American ancestry, its great-great-grandmother being a plant of the American commercial variety "Oregon Cluster" growing in Wye College Hop Nursery. Since 1934 it has been studied both in the trials of New Varieties of hops at East Malling Research Station and at Wye College. The leaflet, which is illustrated, gives cultural details, together with yields, chemical analyses and reports by brewers and merchants on aroma. Although derived from an American variety, Copper Hop has no American aroma, but is mild and pleasant, and of the Fuggle type. The preservative value (P.V.) is considerably higher than that found in the old commercial varieties. The yield is good; it may be mentioned that at Wye, in the unfavourable season of 1954, the cones showed good development and the crop was at the rate of 24 cwt. per acre.

Copper Hop is believed to be a valuable addition to the existing commercial varieties; to the brewer it offers hops with a pleasant Fuggle-like aroma, of exceptionally high preservative value; to the grower, a variety easy to grow and pick, of good yield and with a high degree of resistance to downy mildew and mould (powdery mildew). It is at present grown satisfactorily on a farm in Worcestershire; it is hoped that further planting will take place so that growers can test on different soils its vigour and disease-resistance and brewers be given the opportunity to use different growths for testing its brewing qualities. E.S.S.

G. A. WATSON: "The Drying of Whole and Dissected Hops." *J. Inst. Brewing*, vol. LX, no. 5 (vol. LI n.s.), pp. 400-5, Sept./Oct., 1954.

Whole hops and dissected strigs and bracts have been dried under controlled conditions and their rate of loss of moisture during drying, and rate of re-absorption of moisture after drying, have been measured. The bracts dry much more readily than do the strigs, both when dried on the whole hop and when the two components are dissected out and dried separately. With the varieties Eastwell Golding, Fuggle and John Ford there are no varietal differences in the time of drying of separated strigs and bracts, but differences exist in the drying of the whole hop. Eastwell Golding and Fuggle hops dry at similar rates, but John Ford hops take appreciably longer, the large number and compact nature of their bracts affording protection against dessication.

In the re-absorption of moisture, correctly dried and slightly over-dried hops in direct contact with the atmosphere are found to reach moisture equilibrium within three hours, but under-dried hops, particularly their strigs, will only reach this equilibrium after prolonged contact with the atmosphere. G.A.W.

R. D. HALL (Brewing Industry Research Foundation): "Sulphur in Hop Curing: Influence on Hop Bittering Power"; with an addendum by G. A. Watson, "Curing and Market Evaluation of Experimental Hops." *J. Inst. Brewing*, vol. LX, no. 5 (vol. LI n.s.), pp. 405-9. Sept./Oct., 1954.

A report is given of brewing trials and market evaluation carried out on samples of Early Bird, Petham Golding and Fuggle hops, dried with sulphur treatments: Nil, Normal (with respect to the normal recommendation of sulphur related to the air-speed) and Twice Normal. All unsulphured hops were valued lower than the sulphured hops on the basis of physical appearance, but brewing trials showed that the bittering power of the hops had been depressed by the sulphur treatment. With the Early Bird hops an inverse relation between the hop bittering power and the amount of sulphur used in the drying was found, but this effect was not repeated with the Petham Golding hops. No effect of the sulphur upon the hop alpha resin content was found.

The technique of carrying out tasting trials on experimental brews is described. G.A.W.

Miss C. L. JARY (Hops Advisory Officer, South-East Province, National Agricultural Advisory Service): "The Spread of Progressive *Verticillium* Wilt of Hops." Annual Booklet, 1954, of the Association of Growers of New Varieties of Hops.

The article reviews the history of this disease from the first record in 1924 of the mild "fluctuating" type through the discovery of the devastating "progressive" type at Paddock Wood in 1933, and the research subsequently carried out by Dr. Keyworth at East Malling Research Station, which showed that these two forms of the disease were caused by distinct strains of the fungus; though unfortunately these strains were distinguishable only by their effect on the hop plant itself.

Control measures to check the spread of the disease were worked out and incorporated in the Progressive *Verticillium* Wilt of Hops Order, 1947, which required growers, "with all practicable speed from time to time (to) destroy by fire at the premises where the disease exists all dead or dying bines and leaves of hop plants" and prohibited the sale for planting of any hops grown on infected farms. In spite of this, the disease continued to spread. The earliest survey in 1938 disclosed 20 outbreaks, and thereafter the number increased to 68 in 1941, 104 in 1948, 140 in 1951, until now nearly 200 farms are infected, representing a quarter of the hop farms in South-East England and nearly one-fifth of the total in the whole country. The infected farms are mainly in Kent; mid-Kent and the adjoining Wealden area are the worst affected, but there are also cases in East Sussex and Surrey.

Following confirmation in 1952 of two outbreaks of the "progressive" form of the disease in East Kent remote from the main area of infection, an amendment was made to the original order, prohibiting the movement of hops for planting from the present affected counties to clean areas, and giving the Ministry such additional powers as were necessary to eradicate outbreaks of the disease (as distinct from merely checking them) in hitherto clean areas.

The hope of ultimate control of this disease by new tolerant (resistant) varieties is discussed and reference made to a paper by Dr. Harris of East Malling Research Station on the new wilt-tolerant seedlings which was published in the 1953 booklet of the Association. The potential demand for such seedlings is assessed as 2,500-3,000 acres, but a warning is given that it will be about 10 years before they are available in large quantities. C.L.J.

G. P. CHATER and Miss C. L. JARY: "Hop Picking by Machine"; with foreword by H. S. Darling. Report published by Wye College, Kent. May, 1955. Price 1s.

This report, which was written at the request of the Hops Marketing Board, summarizes the information and experience gained in the various surveys of machine picking carried out from 1949 to 1953 inclusive, under the aegis of the Wye College Department of Hop Research. A stationary machine of a type in common use is described in general terms and detailed notes are given on its operation and management. Several types of machine are referred to and an outline is given of the pros and cons of stationary and portable machines. The question of wastage is discussed in some detail, and mention is made of the problems entailed in drying machine-picked hops.

The report discusses machine picking in relation to the spread of progressive *Verticillium* wilt, and refers in general terms to the growing of hops suitable for the machine. An adequate bibliography is included.

H.S.D.



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